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Hydraulic Flanging Press and Boiler Construction Equipment

Notes from an English Works

Our front page illustration shows a 1,200-ton hydraulic flanging press of English design as utilized at a boiler works at Lincoln, England. These works were erected in 1905 and enlarged in 1910, and consist of an approximately rectangular building divided into six bays running the whole length of the shop. Each bay is 450 feet long by 55 feet wide, the total floor space thus amounting to 17,000 square yards or over 3½ acres.

The first bay is used for the erection of gas producers, but all the other bays are used solely for the manufacture of boilers. Hydraulic pressing, flanging and welding takes place in the second bay, and plating, marking off and drilling in the third bay. Assembling is begun in the fourth bay, where the heavy riveting machines are also located. The fifth bay is devoted to hand riveting and caulking work, and in the sixth, chimneys and ashpans are handled at one end, the plant for hydraulic and steam testing being situated at the other end.

Each bay is served by two overhead electric crane . There is also a 30-ton lifting crane, with a limited traverse within the tower where the large flues are built up vertically as sections are added from below by means of hydraulic riveters. Further, numerous hand and hydraulic cranes are placed in various parts of the shops.

There is a full equipment of up-to-date multiple spindle drilling machines which are used for specific operations. The rivet holes are all drilled after the plates have been assembled in position, through all thicknesses at one setting. The rivets are closed by hydraulic power and the plate edges are planed and the seam afterward carefully caulked and fullered by pneumatic tools.

The 1,200-ton hydraulic flanging press here illustrated deserves special mention. The rams and table provide four separate movements and are specially arranged for such work as pressing the dished ends of large boilers, where the dishing, flanging and finishing of the flue holes is carried out in one heat.

At this boiler plant electric driving is the general rule for the machine tools, but there is also a complete equipment of hydraulic and pneumatic tools. All three forms of power are generated in a separate building situated alongside the boiler works. The power here generated is also supplied to the wood works where threshing machines are made. The main power plant consists of three tandem compound drop valve steam engines, direct coupled to direct-current Siemens generators. The total output at normal load of these generators is 900 kilowatts at 230 volts. Two small high-speed sets of 150 kilowatts are installed as stand-by to supplement the main engines at time of heavy lighting loads. The boilers are of the Lancashire type, fitted with superheaters, mechanical stokers and economizers.

Opening out of the main engine room is the compressor house. The hydraulic pressure employed is 2,000 pounds per square inch and the compressed air pressure 100 to 200 pounds. The hydraulic machinery comprises main and stand-by units and an accumulator loaded with 180 tons. The air-compressors are three in number, two are driven by a tandem compound drop valve steam engine, and the third is a Rand compressor.

A boiler is constructed for every hour and a quarter of the working day and all classes of boilers, except water-tube boilers, are made in these works, a large number being used for the portable steam engines, steam traction engines and road rollers.

TWELVE-HUNDRED-TON HYDRAULIC FLANGING PRESS AT A BOILER WORKS IN LINCOLNSHIRE, ENGLAND

The Art of Enameling*

The Coating of Steel and Iron With Glass

By Raymond F. Nailler

Before considering the technology of any particular type of enamel it will be well to consider the meaning conveyed by the word enamel. If the present day enamel be briefly and scientifically designated as a boro-sodium-potassium-aluminum silicate generally colored by metallic oxides, then the following definition given by Popelin deserves to be quoted since this, notwithstanding its length, may be described as most clear and comprehensive: "Enamel is a glass fusible at a low temperature and usually compounded of borates and silicates. This mixture, originally colorless, combines with the greatest ease with metallic oxides under the influence of a pyrotechnic operation, thereby acquiring various colors according to the nature of the oxide which the enameler can vary at will."

The first step to be considered is the preparation of the enamel. The purity of the raw materials to be used in the compounding of an enamel must be certain and in the cases where materials can vary in strength the actual analysis of the substance must be known to assure proper results. In many cases the secret of an enamel lies in its formula and so the compounding of the batches is very carefully guarded, only a person of responsibility having charge of weighing the ingredients. The various materials are generally kept in bins which are numbered, the person in charge of the mixing having the formula stated in terms of these numbers. The properly weighed batch is thoroughly mixed, this being accomplished either by shoveling carefully on a specially prepared floor or by mechanical mixing by means of a rotating agitator.

The product of the mixing room is taken to the smelter in which the various ingredients are fused together in the form of a mass having the characteristics of glass. The furnace in which this operation takes place is a special reverberatory furnace similar to that used in the puddling process in the manufacture of wrought iron. The coal is placed on a grate at the front end of the furnace and the burning gases pass over the bridge wall, strike the roof, and are deflected against the batch. The first change which may be noted in the smelter is the driving off of the water from the borax which produces a swelling up of the mixture. The fluxing materials then melt down and as the heating is continued, dissolve the more refractory constituents. If the batch is properly stirred and the temperature of the furnace carefully regulated, the product of this operation is a clear transparent glass containing no particles of unfused material. When a test of the fusion comes up to this standard the furnace is tapped and as the liquid glass flows into a tank of cold water it is broken up by the chilling action of the water, the result being a thorough granulation of the product. The material thus prepared is known as "frit."

The next step in the preparation of the enamel involves grinding the frit to a fineness at which it can be applied to the surface of the metal. The mill here used is the ordinary pebble mill lined with porcelain brick and containing very hard flint pebbles. In the cast-iron industry two general processes are used, the dry and the wet, in sheet-steel work only the wet. In the first case the frit is ground dry, the pulverized enamel being sprinkled on the hot cast-iron piece. In the wet process a certain percentage of pure white clay is placed in the mill with the frit and a certain definite amount of distilled water. When certain grades of enamel are to be manufactured, various compounds are also added here to aid in producing desired colors, gloss and opacity. An instance of this is the addition of tin oxide in the mill in the production of white cooking utensil enamels. The fineness to which the enamel is ground depends upon the particular use to which it is to be put, manner of application and other factors. In the wet process the essential feature is that it be fine enough to remain suspended in the water assisted by the clay and the so-called "vehicles" mentioned below.

At this point we may well take up the consideration of the construction and preparation of the material to which the enamel is to be applied. Cast-iron enamels are applied to castings of the desired shape. In the case of cooking ware enamels the shapes are constructed by pressing and spinning. For heavier equipment such as jacketed kettles the apparatus is constructed by riveting or preferably welding the sheet steel in the desired form. The selection of the steel with a view to its chemical analysis is of prime importance. A reliable specification reads as follows:

Sulphur	below	0.040
Phosphorus	below	0.030
Manganese	about	0.40
Silicon	about	0.010
Carbon	about	0.10

The steel must necessarily be free from laminations or other mechanical imperfections.

With reference to the construction of heavy apparatus the sheet ranges from 3-16 inch to 3-8 inch in thickness. Two general methods of construction are in use: The first involves the formation of unit sections fitted with flanges. These sections are enameled separately, bolted together at the flanges and the desired apparatus so constructed. The preferable practice, however, is to construct the apparatus in one piece by means of autogenous welding, thus avoiding the use of gaskets or other packing materials in erection. That the enamel may properly adhere to the surface of the metal, the latter must be free from dirt or scale and in the case of welded joints the welds must have a preliminary grinding to reduce the roughness. The entire surface of the apparatus is then cleaned by pickling or sand blasting, the latter process being altogether used in cleaning large apparatus. As the crude ware leaves the sand blast it has a roughened, clean, metallic surface and is in the proper condition to receive the enamel.

Before applying the enamel to the metallic surface it is prepared by a process known as "setting up." This involves the addition of certain chemicals to the enamel as taken from the mill, the function of this addition being to assist the clay in holding the enamel particles in suspension. Substances so added are termed "vehicles." At this stage the enamel must be diluted with distilled water to the proper consistency for application.

In applying the enamel to the metallic surface three general methods are in use: The first, applicable to small pieces only, is known as "dipping," the piece being dipped into the enamel, the excess of which is shaken off leaving a thin coating on the metal. The second method, known as "slushing," involves pouring the prepared enamel over the surface and allowing it to drain. The third method, which is the principal one used on larger apparatus, involves spraying the finely ground enamel on the metallic surface by means of the compressed air atomizer.

Preliminary to the consideration of firing the enamel we may well review the types of furnaces in use. The first type is known as the muffle furnace and involves the use of a large fire clay oven externally heated by means of coal, gas or other fuel. The apparatus to be fired is placed on suitable supports in this muffle. The other type of furnace is known as the direct fire furnace, in which the heat from the fire is taken up by the walls of the firing chamber and radiated to the apparatus placed within the chamber on suitable racks. This general class of furnace has two special divisions in that, on the one hand, the piece is allowed to remain stationary. For small work the muffle is in general use, but for the production of large apparatus the direct-fire furnace is necessary. At first thought, the muffle furnace may be considered to have an advantage in that the products of combustion together with the dust from the fire cannot come in contact with the enamel. Again it may seem that a more even heat can be realized in the muffle. On the other hand, with a properly designed direct-fire furnace in which the combustion is complete before the gases reach the firing chamber no trouble is experienced due to their presence or to the dust from the fire. The use of natural gas further does away with this latter possibility.

In a furnace for firing smaller ware the charging mechanism is a fairly simple matter, it being necessary merely to place the material in the furnace by means of a small fork operated by hand or mechanically. But in the manufacture of engineering apparatus where a single piece may weigh 3,000 to 4,000 pounds it is necessary to have a large mechanical charging machine on which the piece may be placed outside the furnace, the arm of the machine then properly placing it in the furnace. The general design of such a machine suggests the charger used in open-hearth practice. The apparatus to which the enamel has been properly applied is placed in the furnace which is maintained at the proper temperature. This temperature varies with the nature of the enamel and in cases of high silicon acid-proof enamels reaches in the neighborhood of 2,500 deg. Fahr. The control of the burning is made possible by the changes which occur in appearance of the enameled surface as fusion takes place. At first the fine particles of enamel begin to fuse together and a general blister condition exists, giving the surface a very dull appearance. But as the enamel matures, this dull appearance gives way to a bright glass, which when properly developed over the entire surface is indication that the piece should be withdrawn from the furnace. The time required to burn a piece properly depends upon the temperature of the furnace, thickness of metal and nature of enamel.

Nothing has been said so far as to the composition of the enamel or of the number of coats applied. In general there are two kinds of enamel, known as ground coats and cover coats. The former serves as a bond between the enamel and the steel, and the latter serves to build up the body of the enamel and presents the finished surface. In the ground coat color is no object. Its composition is such as to render it adherent and strong. In addition to the ordinary components cobalt oxide seems to be essential to the production of adherence. The explanation of this is debatable. The cover coat is the one which forms the major part of the enamel and if definite color, opacity, etc., are objects the necessary ingredients for their production are introduced here, assisted by mill additions as noted above. In the manufacture of acid-proof enamel, the cover coat is essentially a high silicate and must be free from any metallic oxides, such as oxide of tin, lead, iron, etc. The piece to be enameled receives one ground coat which is burnt well into the steel at a high temperature. The cover coats may be one or two in number for ordinary enameling, but should be at least triple for acid-proof work. In the production of acid-proof apparatus, the use of a ground coat or cover coat is now eliminated and the same material which in place of being an enamel, as commonly termed, is in reality a boro-silicon glass and without the use of any metallic oxides in its compounding.

It is very interesting to note the chemical changes which take place in the various stages of the production of the finished enamel. Avoiding so far as possible deep technicality, they may be summed up as below. As a starting point let us select a cover coat formula used in the production of a "dark blue" cooking ware enamel.

Feldspar, pound	120
Quartz, pound	72
Borax, pound	80
Cryolite, pound	30
Saltpeter, pound	7
Oxide of Cobalt, pound	7½
Oxide of Manganese, pound	1
Clay in the mill, per cent	4

First considering the behavior of each of the constituents when heated we can later clearly note the general reactions which take place when they are fused together in the smelter.

Feldspar varies greatly in composition but as commonly used in enamels is an aluminum-sodium-potassium silicate of approximately the following analysis:

	Per Cent
Silica (SiO_2)	70
Alumina (Al_2O_3)	17
Soda (Na_2O)	7
Potash (K_2O)	6

On smelting, none of these constituents vaporize so we may consider them all later in the smelting of the above enamel.

Quartz introduced as a pure glass sand contains practically 100 per cent silica (SiO_2).

Borax is chemically known as sodium tetra-borate and in the crystalline form as used has a certain definite amount of so-called water of crystallization which must be taken into account. The formula $Na_2B_4O_7.10H_2O$ is resolved into $Na_2O.2B_2O_3.10H_2O$. Without going through the calculations assume this to correspond approximately to the following analysis:

	Per Cent
Water (H_2O)	16.0
Boric Oxide (B_2O_3)	37.0
Soda (Na_2O)	47.0

Of these the last two do not vaporize on smelting, but the water is evaporated, hence 100 pounds of borax smelts to 84 pounds of the remaining oxides.

Cryolite is a double fluoride of sodium and aluminum, the formula of which may be written Na_3AlF_6. When smelted, the sodium and aluminum appear as oxides and from 100 pounds of cryolite we realize about 24 pounds of alumina (Al_2O_3), 44 pounds of soda (Na_2O) and 54 pounds of fluorine (F_2). There is some dispute

* Paper read before the American Society of Mechanical Engineers.

as to whether or not the fluorine is vaporized. In the present discussion it matters not, hence we shall consider that the third of these three compounds is lost in smelting.

Saltpeter is potassium nitrate KNO_3. When heated under the conditions of smelting it may be considered to break up into potash (K_2O) and nitrogen pentoxide (N_2O_5). The reaction is $2KNO_3 = K_2O + N_2O_5$. By calculations based on this reaction 100 pounds of saltpeter yields about 47 pounds of potash (K_2O) and 53 pounds of the nitrogen oxide (N_2O_5). The latter may be considered as completely vaporized.

Oxide of cobalt (CoO) may be taken as non-volatile and pure. The same may be assumed for the oxide of manganese (MnO_2).

To sum up the above as an outline of the reactions taking place in the smelter

120 lb. Feldspar	gives	$120 \times 0.70 = 84.0$ lb.	Silica (SiO_2)
		$120 \times 0.17 = 20.4$ lb.	Alumina (Al_2O_3)
		$120 \times 0.07 = 8.4$ lb.	Soda (Na_2O)
		$120 \times 0.06 = 7.2$ lb.	Potash (K_2O)
72 lb. Quartz	gives	$72 \times 1.00 = 72.0$ lb.	Silica (SiO_2)
80 lb. Borax	gives	$80 \times 0.16 = 12.8$ lb.	Water (H_2O) (Vaporized)
		$80 \times 0.37 = 29.6$ lb.	Boric Oxide (B_2O_3)
		$80 \times 0.47 = 37.6$ lb.	Soda (Na_2O)
30 lb. Cryolite	gives	$30 \times 0.44 = 13.2$ lb.	Soda (Na_2O)
		$30 \times 0.24 = 7.2$ lb.	Alumina (Al_2O_3)
		$30 \times 0.54 = 16.2$ lb.	Fluorine (F_2) (Vaporized)
7 lb. Saltpeter	gives	$7 \times 0.47 = 3.3$ lb.	Potash (K_2O)
		$7 \times 0.53 = 3.7$ lb.	Nitrogen Oxide (N_2O_5) (Vaporized)
7½ lb. Cobalt Oxide	gives	$7\frac{1}{2} \times 1.00 = 7\frac{1}{2}$ lb.	Cobalt Oxide (CoO)
1 lb. Mang. Oxide	gives	$1 \times 1.00 = 1$ lb.	Manganese Oxide (MnO_2).

We shall consider that of the above the H_2O, N_2O_5 and F_2 are vaporized. This leaves for the constituents of the frit (totals of the above)

	Pounds	Per Cent
Silica (SiO_2)	156.0	53.5
Alumina Al_2O_3)	27.6	9.5
Soda (Na_2O)	59.2	20.3
Potash (K_2O)	10.5	3.6
Boric Oxide (B_2O_3)	29.6	10.2
Cobalt Oxide (CoO)	7.5	2.6
Manganese Oxide (MnO_2)	1.0	0.3
Total	291.4	

The loss, theoretically, on smelting is plainly 317.5—291.4 = 26.1 pounds or $\frac{26.1}{317.5} = 8.2$ per cent. (317.5 pounds = original weight of batch.)

The mill additions together with the agents used in "setting up" are fused with the frit as the piece is fired. By a process similar to the above, we could compute the final composition of the enamel by taking these additions into consideration. The actual amount of material added in this case, however, is so slight and of such a nature that the change resulting therefrom is not sufficient to affect materially the composition of the enamel. When an addition of about 12 per cent tin oxide accompanies the clay, a very significant change in the composition of the enamel is produced.

It may be well to note in passing some of the means by which various colors are produced in the enameling industries. It will be impossible to enter into great detail without taking too much time, but the mention of certain compounds in connection with the colors produced by their use will serve our purpose.

The production of a good white enamel, either for cast-iron or sheet-steel work, may be said to depend, at the present time, upon the use of tin oxide. Great have been the efforts to substitute less expensive substances, such as compounds of antimony and lead. But an antimony white which looks good alone is plainly seen to be off-color when compared with a good tin oxide white.

Going to the other extreme of color, black, we encounter difficulties. There is any number of formulae for black enamels, but when the results are closely compared we find that the colors range widely through brown blacks, blue blacks, purple blacks, etc. Certain compounds of manganese and iron used together give a color approaching black. Other formulae call for the combined use of oxides of manganese, cobalt and copper. Again we find oxide of nickel added to the above three oxides.

A color much seen in enamels is blue and the use of cobalt is very satisfactory in the production of this color in various grades of intensity. Manganese alone produces purples and violets and in combination with cobalt gives various shades of purple-blue.

Green enamels are chiefly produced by the use of chromium oxide and copper oxide, while in some cases a mixture of copper and cobalt oxide is used.

Reds of various shades are produced by the use of red oxide of iron. In connection with it we find that tin oxide aids greatly in giving opacity and bringing out the color. In the production of brown enamels we may use ferrous chromate. Various yellows are produced by salts of cadmium, chromium and uranium.

The more delicate shades of rose and purple are produced by the use of gold compounds. So-called "pink-rose" is used in the manufacture of certain artistic enamels. Perhaps the best known gold compound used in enamel coloring is "purple of Casius." The exact composition of this product is a question. It is made by the combined use of auric, stannous, and stannic chlorides. The color produced is also commonly called "purple of Casius."

Before drawing this paper to a close, attention is invited to a general consideration of the future of the enameling industry. Neglecting art enameling and sign making we come to the field of steel enamels. So far as the cooking ware industry is concerned, the field is practically constant. Granting that the demand for that class of article is increasing, as the public becomes accustomed and educated to its use, there is an opposing tendency in the rapidly increasing use of aluminum ware. Exactly how these and other factors now balance would be difficult to ascertain. But aluminum is a metal and its metallic properties cannot be denied. Under certain conditions it is attacked by various substances used in the culinary arts and a contamination of the preparation is inevitable. No doubt the time will come when a high silica enamel known to be free from tin and other poisonous compounds will enter the cooking ware field. The government is becoming more and more careful in protecting the public from foods of injurious nature and it is not too much to expect that soon it will establish more rigid restrictions relative to the ingredients entering into the manufacture of apparatus in which food is to be prepared. At such a time an enamel coming up to requirement will be free from injurious compounds and will come into great demand.

In the preparation of foods on a factory scale, we find an enormous and constantly increasing demand for larger pieces of enameled steel apparatus in the form of pans, kettles, tanks, pipe, etc. There are many lines of pressure being brought to bear both by the government and public opinion which lead to the conclusion that the increasing demand for this style of apparatus is without limit. Canning and preserving factories and dairy establishments have found a large use for copper and tin in the construction of containers, vacuum pans, etc. The acids of fruit juices and vegetable pulps have a very marked action on these metals and the resulting contamination of the product is known to be of danger to the consumer. The use of an enamel containing tin, lead or other metallic oxides is but the first step in the right direction. The presence of these metallic oxides in the enamel renders it corrodible and contamination results. The solution is the use of an acid-proof enamel free from all such poisonous substances. In the milk industry a similar line of reasoning applies. Further compare the ease of maintaining sanitary conditions in a one-piece enamel lined unit with the trouble experienced in the use of a metal container or even an enameled article made up of composite parts between which are gaskets.

Another consideration relates to the preparation of chemicals later used in food products, for instance, baking powder. Many operations connected with the manufacture of such products have been carried on in lead or other metallic pans and the resulting contamination has given no end of trouble. Acid-proof enamel is rapidly solving this problem also.

Finally consider the chemical manufacturing processes now carried on in apparatus of lead, wood and earthenware, necessitated by the corrosive actions of the liquors and gases involved. This includes the pharmaceutical field which alone is a matter of great importance. In all these and many other lines the use of acid-proof enameled apparatus is rapidly finding and filling a great demand.

Not only does steel apparatus meet the demands of modern industries, but in case a cheaper product is desired and at the same time a heavier construction is permissible, acid-proof cast-iron apparatus has its field. The possibility for size and variety of construction is, of course, more limited than in the case of sheet-steel apparatus.

In view of these considerations and many others which these have called to mind, we cannot but conclude that the use of enameled apparatus has just begun and with this extension of the long known art of metal enameling, a field of great industrial possibilities both for manufacturer and user has been opened. We may not be criticized as being over optimistic when we predict that in their ultimate stage of development the enamel industries will be ranked among the greatest of commercial activities. At such a degree of development the enameling industry will in no way deserve classification among the lost arts.

Horse-Power of Small Gas Engines

THE method of computing the indicated horse-power of a gas engine running at slow or moderate speed follows so closely the procedure for steam-engine practice that seldom any misunderstanding arises. The principal point to bear in mind is that in the $\frac{\text{"}PLAN\text{"}}{33{,}000}$ formula N must represent the number of explosions which in a hit-or-miss governed engine may not bear any definite relation to the revolutions per minute. Moreover, in a gas engine a stiffer spring must be used, owing to the high explosion pressures.

With small high-speed engines running at 800 to 1,000 revolutions per minute the problem is quite different. Here the speed is too high to obtain accurate results with an ordinary indicator; hence, it is usual to estimate the mean effective pressure. The latter, however, will vary with the load and is dependent upon several factors, including the mixture, the compression pressure, and the time of ignition. Therefore, when running underloaded it is practically impossible to arrive at the horse-power, without actually measuring the brake horse-power. The full-load horse-power may be estimated, with fairly close approximation, however, if the cylinder dimensions and speed are known, by assuming a mean effective pressure for full-load conditions. With tight valves and pistons a mean effective pressure of 80 pounds may be taken for gasoline, 75 pounds for natural or illuminating gas and 65 pounds for producer-gas; then substitute this value for P in the formula.

$$\textit{Horsepower (per cylinder)}^* = \frac{PLAN}{33{,}000 \times 12}$$

Where
P = Mean effective pressure;
L = Length of stroke in inches;
A = Area of piston in square inches;
N = Explosions per minute.

This may be written:

$$\textit{Horse-power per cylinder} = \frac{P\,L\,0.7854\,D^2\,N}{33{,}000 \times 12}$$

where D = *diameter of cylinder*

Substituting for gasoline:

$$\textit{Indicated horse-power} = \frac{80\,L\,0.7854\,D^2 N}{33{,}000 \times 12} = \frac{D^2\,L\,N}{6{,}300}$$

Assuming a mechanical efficiency of 85 per cent.

$$\textit{Brake horse-power} = \frac{D^2\,L\,N}{6{,}300} \times 0.85 = \frac{D^2\,L\,N}{7{,}400}$$

This formula may be expressed in other terms to suit special conditions. For instance, in a four-stroke-cycle engine with jump-spark ignition where an explosion occurs at every second revolution, N may be taken as the revolutions per minute and the formula will become

$$\textit{Brake horse-power (per cylinder)} = \frac{D^2\,L\,N}{14{,}800}$$

This is the more familiar form, but it has been further simplified by the American Licensed Automobile Manufacturers Association in assuming a piston speed of 1,000 feet per minute, which is equivalent to a 6-inch stroke and 1,000 revolutions per minute, or, 5-inch stroke and 1,200 revolutions per minute. Using the round number 15,000 for the denominator this reduces to:

$$\textit{Brake horse-power (per cylinder)} = \frac{D^2 \times 6 \times 1{,}000}{15{,}000} = \frac{D^2}{2\frac{1}{2}}$$

This is the formula by which automobile engines are rated.—*Power.*

Clouds and Terrestrial Magnetism

AN entirely new theory concerning clouds, advanced a few months ago by Birkeland, the famous Swedish physicist, seems to be confirmed by a series of observations that an astronomer of the Lyons Observatory, M. Flajolet, has lately made on the *cirri.* These high clouds, that float at more than 9,000 meters high, appear like parallel filaments, or turned over in the form of curls of hair. They often produce halos, and their apparition appears to be related to the variations of terrestrial magnetism. This concordance comes to support the hypothesis of Prof. Birkeland.—*Chemical News.*

***Strictly speaking, this should be "per cylinder per end," but as the present discussion deals only with small engines, which are always built single-acting, the formula may be understood to give the horse-power per cylinder.**

The Modern Car and the Noise Problem

Little Refinements That Make for Silent Running

By Lewis Kingsley

The uninitiated man who observes the extreme quietness of the motor cars to-day as compared with those of two or three years may be excused for concluding that the engines are of totally different construction. As a matter of actual fact, there is very little difference in the construction of the motors, and in seeking an explanation of the velvety smoothness of running, it is necessary to ignore generalities and look into details, for the truth of the matter is that silence has resulted wholly from close attention to the many little things that make up the whole motor. And even the details have not been changed to any great extent; most of the story is told in the exceedingly accurate fitting of all working parts, the natural result of which is an absence of the lost motion that means noise, in the improvements that have been made in the finishing of gears, the teeth of which have been responsible for a vast amount of undesirable sound. Something is due to muffler improvement, and a little to the improvement of combustion and the slightly higher thermal efficiency of the motors of the better types, the result being that the exhaust gases are released at a slightly lower pressure than otherwise would be the case.

Such noises as cannot be overcome many other ways are muffled. The "muffling" method is more or less an extension of the universal practice of enclosing the crankshaft and connecting rods, and putting a casing around the timing gears and the camshafts to protect the parts from dust and dirt and retain the lubricating oil. Now casings are also built around the valve stems and springs, which has the two fold effect of protecting these parts from the intrusion of foreign matter and of imprisoning the clicking of the valve lifters.

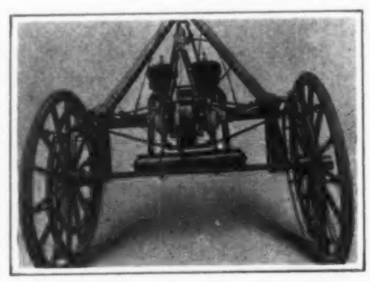
In referring to the quietness of operation of the average car it is only fair to call attention to the fact that the swift rise into prominence of the sleeve-valve motor has had a great deal to do with the elimination of unnecessary motor car noises. What one engineer accomplishes in one way, other engineers will strive to accomplish in other ways, and so it was only a very short time before the poppet-valve motor was silenced to a degree previously considered practically out of the question by most manufacturers. There now are several poppet-valve motors that are practically as quiet as the best of sleeve-valve engines—which is saying a great deal.

The sleeve-valve engine owes its silence very largely to the absence of mechanism of the type employed to operate poppet valves, which necessarily operates more or less suddenly and is accompanied by a pounding action that developes noise easily and is difficult to construct so as to work noiselessly. The sleeves are moved by short rods actuated by eccentrics—one of the smoothest known methods of changing rotary to reciprocating motion—and, provided there is no looseness in the moving parts, there is nothing to rattle or clatter. In the poppet valve motor, however, there are many possible sources of sound. The cam, if of incorrect form, may, at high speed, raise the push-rod roller and toss it off the apex of the cam, so that it leaves the cam face for an instant and returns to it with a slight but sharp click. There is apt to be a click when the valve lifter in rising comes in contact with the bottom of the valve stem—in fact, it is a difficult matter to dispose of this noise, because if the lifter is so adjusted that there will be no clearance and consequently no hammering and noise, the expansion of the parts under heat will result in the valves being held off their seats when they should be closed, thus allowing leakage past the valves, and consequent loss of power, back-firing through the carbureter and the general demoralization of the operation of the engine. The valves themselves necessarily come down on their seats with a rather smart blow, and not infrequently this hammering of valves is distinctly audible at high speeds. In motorcycle engines, which are air-cooled and therefore lack means of smothering this sound, the valves often can be heard quite plainly.

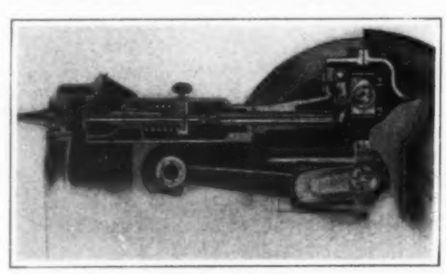
By skilful designing in the matter of cam contours and by the use of springs of the correct strength noise caused by valve lifter rollers "jumping" on the cam faces can be avoided. The hammering of the valve in its seat also is greatly mitigated by the use of a cam which permits of a seating that is gradual rather than abrupt—if the term gradual can be applied to anything moving at the speed at which these valves move. At any rate, what with good cam design and the decidedly efficient muffling effect of the water jackets, the hammering noise of valves in water-cooled motors has become quiet uncommon. The clicking of the valve lifter on the end of the stem is an even more difficult matter to overcome, however, and while fiber pads often are used with good effect, in most cases there always remains more or less of a clickety-click, clickety-click when the motor runs, and this fact is largely responsible for the casings around the valve stems that are a feature of so many of the motors built to-day.

Of all the motor noises, however, the most difficult to get rid of have been those resulting from the use of gears for driving the camshafts, magneto, pump and so on.

The speed at which these gears run, the intermittent character of the resistance opposed to their rotation, together with the somewhat limited width of face, which permits wear, makes it extremely difficult to turn out gear drives that will be as noiseless as the balance of the motor; and even if such gears should run silently when new, the wear that is inevitable brings with it a backlash that necessarily produces noise which increases in volume as the wear proceeds. It is true that some wonderfully quiet gear drives have been produced, and that their durability has been quite remarkable; but these ends are accomplished only by the employment of the most expensive materials and methods, of the utmost care in selecting sets of gears that will be run sweetly together, and of a "running-in" process that requires time and skill. In order to accomplish the same result—silent operation—by a more direct and less expensive method, there has of late been a strong tendency to adopt the silent chain drive for the work usually performed by the timing gears. These chains, which have links forming teeth that run accurately in corresponding teeth cut in the broad-faced sprockets, are, to all intents and purposes, absolutely silent when operated under proper conditions. There is a slight cushioning effect due to the almost infinitesimal lost motion and slackness in the joints, the minute spaces being filled with oil, and this effectually prevents noise from back-lash.

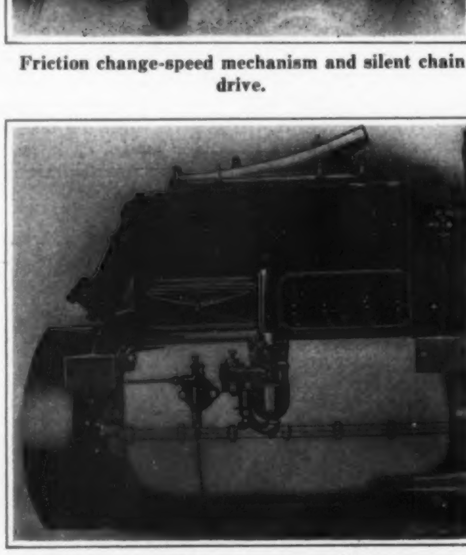


Gearless and noiseless roller transmission.



Inclosed valve mechanism with silent valve-lifting gear.

Friction change-speed mechanism and silent chain drive.



Method of inclosing valve-stems and springs.

There are several mechanical features employed in cars that are conducive to silent running, though not a few are distinctive features of certain makes of machines. For instance, there are cars of the friction-drive type in which there are absolutely no gears in the power transmission system. A typical drive is from a friction disk on a rearward extension of the engine shaft to a second disk mounted on a countershaft at right angles to the engine shaft, the countershaft disk being slidable along the shaft so as to make contact with the driving disk at any desired distance from the center, for the purpose of changing the relative rates of rotation; from the countershaft to the rear axle of the "live" type silent chain transmission is used. In such a system the only gears are those in the differential, which are in actual operation only occasionally. Somewhat extensive trials have been made of change-speed mechanism in which all the forward speeds except the high speed—which is direct—are obtained through silent chain drive. In a drive of this type the various speeds are controlled through individual clutches. The reverse is obtained through spur gears, for the use of chains for this purpose presents difficulties.

There is still another type of driving mechanism which not only eliminates absolutely all gearing, including the differential, but also does its work without chains. In this mechanism, which is giving results in actual service, the motor, which is of the air-cooled two-cycle type and has two cylinders with the flywheel between them, is mounted on a frame between the driving wheels, forward of the rear axle and a little above it. The crankshaft is extended lengthwise and is carried across the machine, so that its extremities, to which two grooved rollers are attached, are in line with large friction rings attached to the wheels of the car. The engine turns its shaft, of course, and the rollers on the ends of the shaft transmit the power to the friction rings on the wheels. Slip is relied upon to allow for differential action in making turns. The power is thrown off by the simple process of shifting the whole engine slightly forward so that the rollers move out of contact with the friction rings; while a further forward movement brings the rollers in contact with the inner circumference of a second pair of rings, which gives the reverse. Obviously there is nothing in this drive that can make any noise whatever.

The most recent development in silent driving mechanisms, and at least one of the most interesting, is the worm drive. For many years it has been familiar as a drive of great utility under certain conditions, and as a compact but inefficient method of obtaining large speed reductions. Owing to lack of familiarity with its possibilities, however, it was not until quite recently that it was seriously considered as a motor car final drive. The worm gear is peculiar in that it involves continuous rubbing contact—the very thing that all designers of gears have sought to avoid. Nevertheless, scientific designing and extremely accurate workmanship, together with the employment of the remarkable steels and bronzes that have been brought into existence chiefly through the influence of the motor car, have been combined and worm gears produced that equal and even exceed bevel gears in mechanical efficiency and durability, while far surpassing them in the matter of noiselessness—in fact, a worm drive is truly silent, in the real meaning of the word.

The quietness of a good gasoline car is such that the rushing sounds of the gases passing in and out are plainly audible, and sounds that only a short time ago were considered absolutely negligible now have become rather serious problems. For instance, the sound

of the air being sucked in through the carbureter has assumed such relative proportions that in some cases carbureters have been fitted with means for muffling the hissing so made. One maker of a particular type of ignition apparatus which made a slight clicking has redesigned the whole instrument, at no small trouble and expense, and so eliminated the objectionable snapping. And while it is doubtful if a gasoline car ever can be made quite as soundless as the ghostly electric, it can be, and is, so quiet that the rush of air in the passengers' ears is quite enough to drown out the slight noise that is given forth by the mechanism.

How We Get Standard Time

Striking a Compromise Between Theoretical and Practical Demands

By Harlan T. Stetson

Although it may be generally known that the determination of time is the work of the astronomer, yet doubtless few people stop to investigate the precise methods employed in the correction and distribution of standard time. It is a system in itself quite indispensable to the success of the industrial world.

The great universal timekeeper is the earth itself. So uniform is the earth's rotation on its axis, that the length of the day according to Newcomb has not altered the 1/100th, and probably not the 1/1000th part of a second since the beginning of the Christian era. The direct effect of this rotation is the apparent revolution of the celestial sphere, or the daily motion of the sun, stars, and planets across the sky. As places on the earth are determined by latitude and longitude, so stars are located by right ascension and declination. Every conspicuous star has its position carefully determined, and from a star catalogue the astronomer knows at once the instant of culmination or meridian passage of any given star. If then with a suitable instrument an observation of a star's transit across the meridian can be obtained, and the time of its occurrence be noted by a clock or chronometer, a comparison with the catalogue will disclose the amount by which the clock or chronometer is fast or slow. Such an operation of finding the clock error is always what astronomers understand by the expression "obtaining time." The instrument used for making these observations is known as the transit instrument, and consists essentially of a telescope so mounted as to be capable of swinging about a horizontal axis in the plane of the meridian. The accompanying illustration shows such an instrument ready for the observation. In the eye-piece of the telescope is placed the reticle, comprising a number of spider webs, of which the attached diagram shows five to be stretched vertically and two horizontally across the field of view. The instrument is so adjusted that the middle one of the vertical threads coincides as nearly as possible with the imaginary circle in the sky called the meridian.

When observations are to be made for determining time, the astronomer first turns to the Ephemeris or some catalogue of stars, and selects a star which is soon to culminate, then from the declination he mentally calculates the altitude at which the star will transit. By means of a reading circle attached to the instrument he sets the telescope at the proper angle, so that the star will pass through the field of view. Either of two methods may now be employed in making the observations. The first and older of the two is known as the "eye and ear" method. This consists of watching the star pass through the field, and while listening to the half-second beats of the chronometer, estimating to the nearest tenth of a second the time at which the star crossed each thread of the reticle. In the "chronographic method," now much used, the mind has less to do, and hence more accurate results can be obtained. Here as before the astronomer watches the passage of the star across the threads of the reticle, but instead of es imating the time of transit, he presses a telegraphic key at the proper instant. The key is in electrical connection with an instrument called a chronograph, and an automatic record is made of each observation. Either method will leave a record for the five threads similar to the following, the Roman numerals designating the number of each thread in order of observation:

I	16.7
II	25.5
III	34.3
IV	43.0
V	7h. 9m. 51.7s.
Mean	7h. 9m. 34.24s.

The above is the actual result of a set of observations made by the writer, using the eye and ear method. The figures in the "seconds" column were written immediately after the transit of each thread; the hour and minute were filled in at leisure after the last observation.

The mean of these observations will give a more precise result for the transit over the middle thread than a single observation could afford. The exact right ascension of the star we will suppose to have been known as 6h. 58m. 35.95s., which equaled the correct time of the star's transit. The chronometer, however, recorded the time of transit as 7h. 9m. 34.24s., and was therefore fast by the amount of 10m. 58.29s.

Were the instrument in perfect adjustment, and were there no personal element to enter into the result, such a set of observations would be quite sufficient. As a matter of fact, however, there are always small errors in the instrument, which must be determined and applied as a correction to the final result. The astronomer therefore does not rely wholly upon a

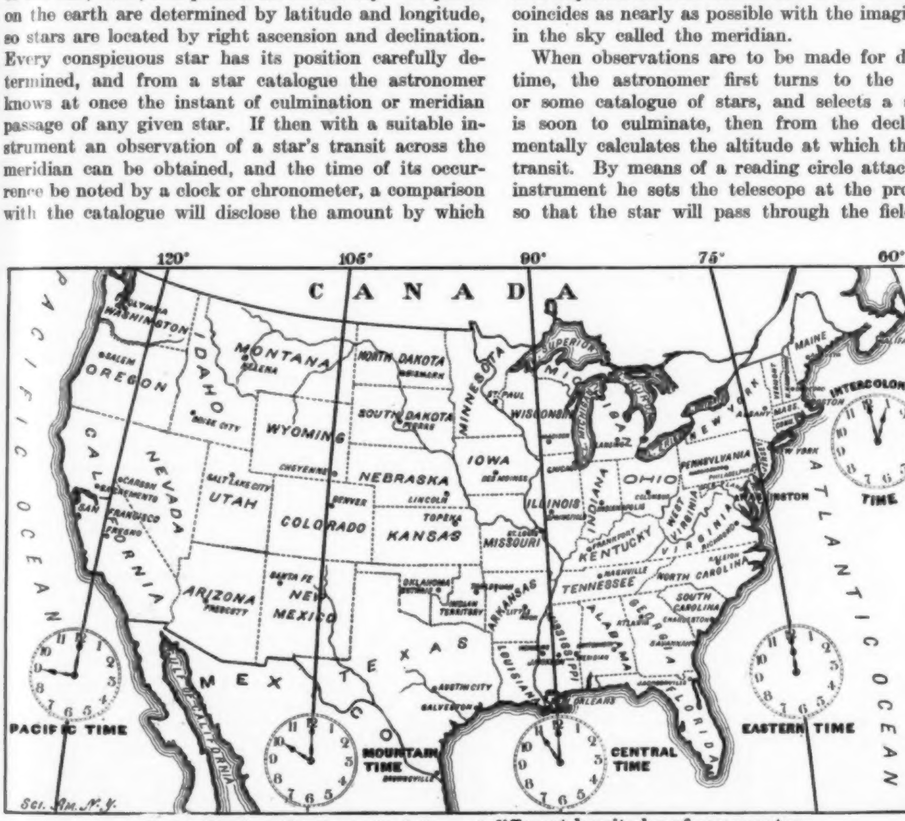


Chart showing the theoretical time at different longitudes of our country.

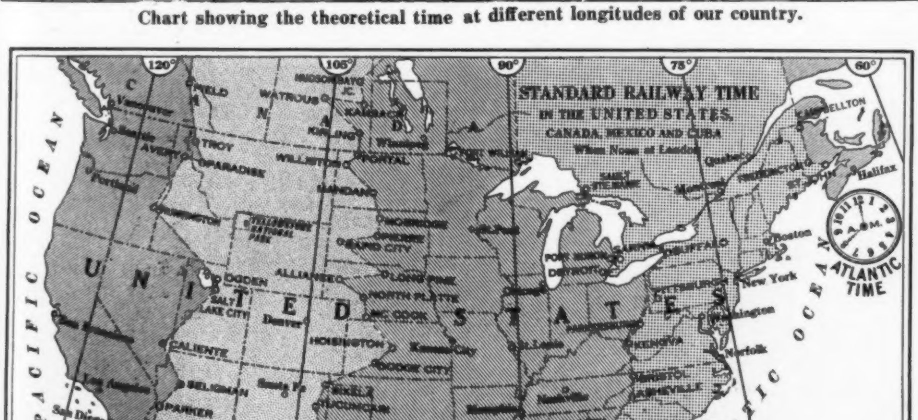
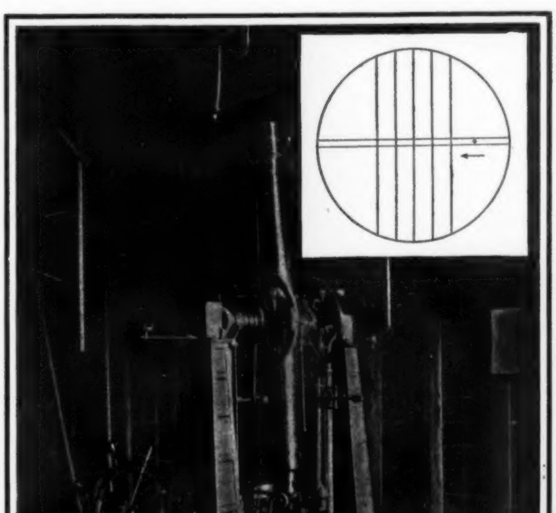


Chart showing how a practical compromise is effected to make local time agree approximately with the theoretical.



An observatory transit instrument for determination of standard time. Diagram shows reticle of transit.

single record like the above, but will usually repeat the observation with a number of different stars on the same night. From these numerous records he is able to deduce the necessary corrections, and thus obtain a more accurate value for the chronometer error. Time thus determined, ordinarily correct to within one tenth of a second, is *sidereal* time; and though very useful to the astronomer, is quite unsuited to the use of the world in general, whose activities are governed by the rising and setting of the sun, and not the stars. Sidereal time must therefore be converted into *solar* time. This is easily effected by a simple calculation constantly employed by the astronomer. Having then obtained solar time, there remains only to distribute it to the outside world.

Until within the last twenty-five years each community used its own local time, but as travel became more extensive it was found quite inconvenient to alter one's watch and system of time reckoning for every few miles of traveling east or west. Accordingly, in the year 1883 the United States adopted the present system of standard time. The whole country from the Atlantic to the Pacific was divided into time belts of approximately fifteen degrees in width. The "Eastern" belt, extending as far west as Buffalo, uses the time of the 75th meridian, which is very nearly that of Philadelphia, and is five hours slower than Greenwich time. Crossing into the "Central" belt, watches are set one hour earlier, as the time employed is that of the 90th meridian, six hours behind Greenwich time. Similarly, "Mountain" time uses the 105th meridian, seven hours behind; and the "Pacific" belt adopts the 120th meridian time, just eight hours slower than that of Greenwich. Such a system is quite indispensable to railroad lines, and hence standard time is sometimes called "railroad time." At present almost every civilized country is using some system of standard time, usually under the control of its own government.

The chief source for standard time in the United States is the Naval Observatory at Washington, D. C. Here high-grade clocks are carefully regulated by observations of the stars at night, and all necessary corrections applied. For the five minutes preceding noon of each day, eastern time, the Western Union and Postal Telegraphic companies suspend all ordinary business, and throw their lines into connection with the Washington Observatory. It is so arranged that the sounders all over the lines make a stroke each second during the five minutes until noon, except the twenty-ninth of each minute, the last five seconds of each of the first four minutes, and the last ten seconds of the fifth minute; then follows the final stroke at exact noon.

This affords many opportunities for the correction and setting of timepieces throughout the country. The Western Union Company also operates a system of some 30,000 clocks, which automatically set themselves by the noon signal each day.

In addition to the Washington signals, many smaller observatories determine and distribute time in a similar way to jewelers and local railroad lines. In most of the larger seaports, time balls are dropped at noon, and give mariners an opportunity to correct their chronometers. Fire-alarm companies aid in the distribution of time in many localities by sounding bells at certain specified times each day, thus affording the public over large districts a thoroughly convenient source of "correct time" with a reasonable degree of accuracy.

Bridges in Relation to the Hudson River*

The Cost of Construction Threatens To Become Prohibitive

By G. F. Kunz, Ph.D., Sc D.

Some years ago, the proposal to erect bridges across the Hudson River at several points between the upper part of Manhattan Island and the New Jersey shore was actively discussed, and plans were prepared for such structures. But more recently the successful construction of tunnels has been accomplished, while the difficulties in the way of bridge erection have come to be recognized; so that of late little has been heard of the latter project, and attention is being more and more directed to the former. Thus far, however, the tunnels opened have been made only for railroad cars. These are already introducing great changes and accommodating passenger travel on an extensive scale but there remains a vast and ever-increasing amount of freight and automobile traffic which is still dependent upon the ferries and liable to all the delays and interruptions of bad weather during the winter months. To meet this demand, either bridges or tunnels must be provided; the former involves great difficulties, even if possible at all, and their cost would be enormous; while tunnels can be built at far less expense—several, indeed, for the cost of a single bridge.

In the attempt to bridge the Hudson the problem at once encountered is the breadth of the stream. With our present engineering experience, no bridge can be safely built with a single span exceeding three thousand feet. This is about double that of the suspension bridges over the East River to Brooklyn, and reaches the limit of security. The Hudson at New York exceeds this limit considerably even at its narrowest point. Supporting piers, one or more, between the ends of the span are therefore an absolute necessity, and these piers must of course rest upon rock. But the rock bottom lies so far down that it is impossible to use it for this purpose, on account of the enormous expense.

The narrowest part of the river within the City limits is at One Hundred Seventy-ninth Street, and plans were made and boring taken for a bridge at that point, from Fort Washington to Palisade Park, N. J. The Bridge Commission, in investigating that site, did so believing that the two banks of the river would act as supporting piers for the bridge, but even there it would be necessary to have intervening piers, as the width is a little over 3,900 feet.

Another investigation was made at a point some three and a half miles below, at One Hundred and Ninth Street, but here the width is 4,400 feet. Other proposed locations for bridges were at Fifty-ninth Street, Thirty-third Street, and Twenty-second Street. As the river widens below, no definite proposals have been made for bridge construction lower down.

For long bridges of single-span, two types alone are available—these being the suspension bridge and the so-called cantilever. A third type, known as the arched-rib, which is essentially a suspension bridge reversed, as shown by Prof. W. H. Burr in the Scientific American Supplement (No. 1252, December, 1899), while handsome and useful for many purposes, is less adapted to spans of very great length. The cantilever design has been employed in several noted structures, particularly the celebrated Forth bridge in Scotland, the finest example in the world; the ambitious but ill-fated Quebec bridge over the St. Lawrence river; and the Queensborough bridge from New York to Long Island. Of these, the first, built over the Firth of Forth by Sir Benjamin Baker, is constantly traversed by heavy railroad trains which pass over it without slackening their speed of fifty miles an hour, and has stood with perfect stability and security for over twenty years. It has a central pier, with two lateral spans of 1,710 feet, to the piers at either side.

The Quebec bridge was heralded as the longest of its kind in the world, having a clear span of 1,800 feet between piers—a central section being sustained by the cantilever arms on both sides. But, alas for human calculations! This structure collapsed under its own weight in August, 1907, falling in utter ruin before completion, with a loss of many lives. An elaborate investigation by the Canadian Government showed various defects in both the plan and the methods of construction.[1]

The immediate cause of the collapse, as determined by the Royal Commission appointed to investigate the matter, was "the failure of the lower chords in the anchor arm near the lower pier." The Commission found that this failure of the chords was neither due to the use of poor material nor to atmospheric conditions, but to defective design. Moreover, the unit stresses given were higher than any warranted by practical experience, and the dead load was estimated at too low a value. In the words of the report, "This error was of sufficient magnitude to have required the condemnation of the bridge even if the details of the lower chords had been of sufficient strength."

In conclusion the Commission state that in their opinion "the professional knowledge of the present day concerning the action of steel columns under load is not sufficient to enable engineers to economically design such structures as the Quebec Bridge. A bridge of the adopted span that will unquestionably be safe can be built, but in the present state of professional knowledge a considerably larger amount of metal would have to be used than might be required if our knowledge were more exact."[2]

As to any bearing upon the question of bridging the Hudson by a cantilever structure, it is enough to note that the entire length of this bridge was 2,800 feet, and the length of the main span 1,800 feet, the latter extending across the St. Lawrence, with two "anchor spans" of 500 feet on each side, from the shore to a main pier; while the narrowest part of the Hudson at New York, as already stated, is 3,900 feet, at Fort Washington.

It is true that at least one design was made for a cantilever bridge over the Hudson, of 3,100 feet span between piers; but this was only for comparison with a suspended structure of equal length, and showed that the latter would be much less heavy and less costly.

Several designs were made for suspension bridges in the years between 1896 and 1900, and a brief account of these may be given here, as matter of history.

The type employed in all these designs is that shown as the "stiffened suspension" bridge, viz., a suspended structure with strengthening trusses extending along each side, to give greater rigidity and to distribute the strain of what is called the "live" or moving load, such as railroad trains, etc. The strains or stresses upon a bridge are of three principal kinds: (1) The actual weight of the structure itself, which is of course, constant, and vertical; (2) the effect of wind, which is chiefly lateral, and varies greatly in both amount and direction; and (3) the moving or "live" load, which likewise varies constantly, and also acts unequally at different points. The truss-work, although it adds very materially to the weight of the whole structure, tends nevertheless so much to equalize and distribute the stresses of the second and especially of the third class, that it is now employed in all, or nearly all, long suspended structures. It is usually carried along the line of the roadway, as well shown in the three suspension bridges over the East River, but may also be combined with the cables themselves, as a bracing connecting an upper and a lower set. This latter, known as the "trussed cable" type, may be developed in several ways, and was proposed in one or more of the designs for bridging the Hudson.

The board of engineers charged with the consideration of proposals for such structures, adopted for them a length of 3,100 feet, believing that suitable tower foundations could be obtained far enough out from each shore to make this the limit of the clear span.

One striking and beautiful design was that prepared by Mr. Gustav Lindenthal, the eminent bridge-builder, for a bridge from Twenty-second Street to Castle Point at Hoboken.[3] It had at the ends, 3,100 feet apart, two double towers, each curving upward from a spreading base, in the form of the Eiffel Tower at Paris. One system of truss-work extended, as in the Brooklyn bridges, along the roadway from shore to shore; while another was provided with the cables. These were double for their whole length, forming on each side two parallel curves one above the other, connected vertically by cross-bracing. Between the towers and the shore ends these trussed cables passed from above the roadway to beneath it, crossing the other system at this point, and then were carried on to the anchorages. This type of construction had already been used by Mr. Lindenthal at Pittsburg and St. Louis, and has been employed somewhat also abroad.

Another design was one that received the approval of the Secretary of War.[4] This had a simple cable system extending from the towers, which were 3,220 feet from center to center, and vertical suspenders carrying a horizontal roadway flanked by a large, high and powerful truss system 3,100 feet long. The trusses were not continuous, as in the Brooklyn bridges, or the Lindenthal design, but double—two joined at the center of the bridge. From the towers to the shore ends, about 1,000 feet, extended a smaller system of trusses, beneath the roadway, with three small supporting towers some 250 feet apart.

Another design, somewhat similar but with important differences, was prepared by Mr. George S. Morison, of the American Society of Civil Engineers.[5] Like the last, this had a simple system of four cables, sustaining a nearly horizontal roadway by vertical suspenders.

*Reprinted from Appendix B of the Eighteenth Annual Report of the American Science and Historic Preservation Society.

[1]Royal Commission Quebec Bridge Inquiry, Report, Ottawa, 1908.

[2]Royal Commission's Report, p. 10.

[3]Scientific American Supplement, No. 1252, Dec. 30, 1899, fig. 8, and Scientific American Supplement, No. 1253, Jan. 6, 1900, fig. 1.

[4]Scientific American Supplement, No. 1253, Jan. 6, 1900.

[5]Scientific American Supplement, No. 1001, Nov. 28, 1896.

But the truss system was different; it was not only continuous, but was made 1,000 feet longer than the span, being carried back 500 feet from each tower. The trusses were thus 4,100 feet long, their extremities resting upon small supporting piers, whereon they would be free to move in expansion and contraction, and there connected with a shore-span at each end in the form of a cantilever some 500 feet in length, supported, of course, on a small pier of its own. Mr. Morison laid much stress on the superior advantages of the continuous truss, as compared with the double one hinged at the center, and on the cantilever connection at the ends.

A fourth design,[6] more like the second described, presented yet a different appearance. Four heavy cables, not in two sets as in the last, but about equidistant laterally sustained the roadway by vertical suspenders. But a striking aspect was given by the truss system; this was joined at the center, but instead of being parallel throughout, extended from tower to tower in the form of two low arches, rising to half the height of the towers at a distance midway from each to the center of the bridge. The light and lofty character of these arched trusses and the intersection of their upward curves with the catenary of the cables, presented a peculiarly elegant and graceful aspect.

Either of these designs, if carried out, would have yielded a beautiful and impressive structure, of magnificent proportions—a very triumph of engineering skill. A bridge of such unprecedented length, spanning so noble a river, would have been a matter of not only local but national pride. Its construction was desired and hoped for by many citizens of New York for years, but appears now to be improbable. It is not indeed impossible; but the cost of constructing foundations at the depth necessary to reach the rock is practically prohibitive It has been calculated that such a bridge would cost from one to two hundred million of dollars—a sum which would equal a tax of ten or twenty dollars on every man, woman and child in the States of New York and New Jersey.

[6]Scientific American Supplement, No. 1252, Dec. 30, 1899, fig. 6.

Although not directly a Hudson River bridge, reference should be made here to the magnificent arch which is to cross Hell Gate to connect the Pennsylvania and New Haven railroad systems, instead of the long ferry trip around New York Island as now involved. From Long Island City to the Bronx is to extend a great steel viaduct over three miles long, crossing the islands and channels of the upper East River, and passing over Hell Gate by a bridge of 1,000-foot span, the largest arch in the world.[7] This noble structure was planned by Mr. Gustav Lindenthal, already referred to, and was approved by the Municipal Art Commission. The East River will thus be crossed by bridges representing the three types of construction—the "stiffened suspension" type in the Brooklyn, Manhattan, and Williamsburg bridges; the cantilever in the Queensborough bridge; and the "arched rib" type in the one at Hell Gate. At the shore-ends will be handsome massive towers of granite and concrete, between which will extend a very graceful but most powerfully built double arch of steel truss-work 1,000 feet long, 140 feet high at the towers, and 40 feet high at the center. From this (truly a reversed suspension bridge, as Prof. Burr expresses it)[8] the roadways will be hung by suspenders, carrying the four tracks in a straight line about a hundred feet above the water.

The foregoing table gives the principal data concerning the bridges over the East River:[9]

BRIDGES OVER THE EAST RIVER—GENERAL DATA.

	Brooklyn Bridge.	Manhattan Bridge.	Williamsburg Bridge.	Queensboro Bridge.
Type	Suspension	Suspension	Suspension	Cantilever
Length, river span	1595.5 ft.	1470.0 ft.	1600.0 ft.	1182 and 984 ft.
Length, main bridge	3455.5 ft.	2920.0 ft.	2793.0 ft.	3724.5 ft.
Length, Manhattan approach	1562.5 ft.	2067.0 ft.	2650.0 ft.	1052.0 ft.
Length, Brooklyn approach	998.0 ft.	1868.0 ft.	1865.0 ft.	2672.2 ft. (Queens)
Width, over all	86.0 ft.	122.5 ft.	11 8.0 ft.	89.5 ft.
Tracks, elevated railway (or subway)	2	4	2	2 (Dec. 31, 1912)
Tracks, surface railway	2	4	4	4
Roadway	Two 16 ft. 9 in. wide	One 35 ft. 0 in. wide	Two 10 ft. 11 in. wide	One 53 ft. 3 in. wide
Footwalks	One 15 ft. 7 in. wide	Two 13 ft. 7 in. wide	Two 17 ft. 8 in. wide	Two 16 ft. 4 in. wide
Main trusses, height, c to c pins	17 ft. ½ in.	24 ft. 0 in.	40 ft. 0 in.	45 to 185 ft.
Main trusses, panel length	7 ft. 6 in.	18 ft. 1 3-16 in.	19 ft. 11 in.	43 to 80 ft.
Elevation above M. H. W.—cable at tower	+272.0	+322.5	+333.0	+323.0 (top chord pin)
Cables, number of wires	5,296	9,472	7,696	....
Cables, diameter, each wire	0.165 in.	0.192 in.	0.192 in.	....
Cables, total diameter	15.75 ft.	21.25 in.	18.625 ft.	....
Cables, length c to c anchorage pins	3578.5 ft.	3224 ft.	2985 ft.	....
Total steel in main bridge	11,920 tons	41,680 tons	28,700 tons	54,200 tons
Total steel in Manhattan approach	10,200 tons	8,150 tons	10,500 tons	6,000 tons
Total steel in Brooklyn approach		7,620 tons	6,085 tons	13,600 tons (Queens)
Total masonry, main piers	85,160 cu. yds.	79,600 cu. yds.	45,500 cu. yds.	53,000 cu. yds.
Total masonry, anchorages	56,620 cu. yds.	228,500 cu. yds.	112,800 cu. yds.	
Cost of construction, including terminals	$16,091,580	$14,104,900	$14,181,560	$13,496,500
Construction of masonry piers started	Jan. 3, 1870	Oct. 1, 1901	Nov. 7, 1896	July 19, 1901
Construction of steelwork started	May 29, 1877	April 30, 1906	Feb. 21, 1899	Nov. 20, 1903
Roadways opened	May 24, 1883	Dec. 31, 1909	Dec. 19, 1903	Mar. 30, 1909
Cars first operated, Brooklyn surface	Jan. 23, 1898	Sept. 4, 1912	Nov. 3, 1904	10–4–09, N.Y. & Q. Co.
Cars first operated, New York surface	....	Nov. 14, 1912	Feb. 9, 1905	Jan. 24, 1912
Trains first operated, elevated	Sept. 24, 1883	....	Sept. 16, 1908	....
Travel, both directions for 24 hours, 10–24–12:				
Elevated railway cars	7,490	....	1,944	....
Surface railway cars	8,017	482	9,088	2,796
Vehicles	3,913	4,823	5,924	3,644
Passengers, elevated railway cars	211,117	....	72,648	....
Passengers, surface railway cars	119,893	4,798	155,195	50,852
Passengers, vehicles, including driver	5,976	8,314	10,878	7,819
Pedestrians	7,282	1,498	2,168	1,153
Total number of people crossing	344,268	14,610	240,889	59,824
Per cent of total of 4 bridges	52.2%	2.2%	36.5%	9.1%
Cost of property	$7,100,000	$12,470,000	$9,096,000	$4,635,000

To build a bridge of any of the types proposed for the Hudson River, it would be necessary to have one or more piers; either two piers one third of the distance from each shore, or one pier in the center of the river. An absolutely essential condition for this is that the river-bed should be of sufficient compactness to yield a firm foundation—a condition that could only be satisfactorily fulfilled if rock were present at a reasonable depth. An illustration of the difficulties involved may be found in the case of the bridge across the Firth of Forth, where the single span requires for its support two structures similar to the Eiffel Tower. Therefore the Bridge Commissions, and all those who for the past twenty-five or thirty years have hoped and dreamed that the Hudson River would be bridged, are probably doomed to disappointment.

In the meantime, however, it is perfectly possible to construct many tunnels under the river. The discussion of this topic must, however, be reserved for another occasion.

[7]Scientific American, vol. xcvi, No. 23, June 8, 1907, p. 468.

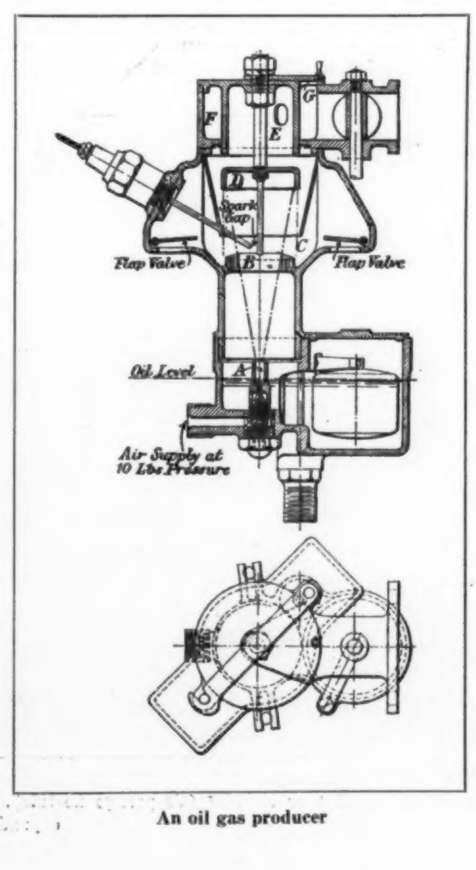
[8]This table was furnished to the author through the courtesy of Hon. Arthur J. O'Keeffe, Commissioner of Bridges, April, 1913.

[9]Scientific American Supplement, No. 1252, Dec. 30, 1899, p. 20,070.

An Oil Gas Producer

A suction gas producer, using oil as fuel, has been developed in Luton, England. The apparatus, while primarily intended for motor cars, is available for stationary engines, and a 15-horse-power Crossley gas engine has been operated for a considerable period on gas made in one of these producers. The apparatus is shown in the accompanying illustration. It is a combined producer and carbureter, in which only a portion of the fuel is gasified, the remaining portion reaching the cylinder as vapor. The heat necessary for the evaporation of this portion of the fuel is supplied by the partial combustion in the producer of part of the fuel actually fed. The air supply for this combustion is restricted, thus converting the carbon in the fuel into carbon monoxide.

Referring to the illustration, the float chamber at the right contains the fuel oil at the proper level. Compressed air, at a pressure of from 7 to 10 pounds per square inch, is pumped through the ejector *A* and sprays a portion of the fuel, as indicated by the dotted lines in the illustration. The edges of the jet are cut off by the diaphragm *B*, and the intercepted particles fall back into the oil supply at the bottom of the producer. The remaining oil passes into the combustion chamber *C*, at the top of which is a baffle *D*. The whole of the spray is intercepted by this baffle and falls to the bottom of the chamber *C* and through the small holes therein back into the oil tank. If, however, the engine is at work, the suction thereof draws air through the two float valves and the oil spray in the combustion chamber is ignited by the spark passed across the gap shown. Due to the restricted air supply, however, only partial combustion ensues, burning the fuel to carbon monoxide and liberating hydrogen. These gases together with some of the ungasified portion of the spray pass through the hole *E* and around the annulus *F*, through the throttle valve, into the cylinder. The air necessary for the completion of the combustion in the cylinder, enters at *G*, being regulated in amount by the slide. The ignition of the mixture of the chamber *C* by a spark is necessary only at starting. Combustion will continue thereafter as long as the engine is in operation. The air supply necessary for spraying the oil is obtained from one of the engine cylinders and no air reservoir is necessary. A special valve in connection with a filter is interposed between the cylinder and the bottom of the producer. This special valve is provided with two seats, seating on one when the cylinder pressure is too low, and on the other when the pressure is too high. Connection with the producer is established only when the cylinder pressure is between 7 and 10 pounds. The body of the producer is of gun-metal and rarely becomes so hot that it cannot be touched. After continuous use, a slight deposit of soot is found on the walls of the chamber *F*. This, however, may be readily removed if necessary.—*Engineering Digest.*



An oil gas producer

Radium Fixes On to the Skeleton

M. Dominici and M. and Mdme. Laborde have injected into animals radium salts in a soluble state, and have searched the place of fixation. Fragments of bone tissue having appeared constantly radioactive during the experiments, the experimenters have tried to make a precise departure between the quantities of radium fixed by the skeleton, the muscles, the viscera, and the skin.

A rabbit was killed thirty-three days after an intravenous injection of 0.06 milligrammes of pure radium associated with an equal quantity of bromide of radium. All the skeleton separated from the muscles, tendons, then the muscles, viscera, and skin, have all been burned separately. The ashes, weighed and analyzed, showed that the radium was fixed on the skeleton rather than on the other parts of the organism, where it is found in only very feeble quantities. In their communication to the Biological Society, MM. Dominici and Laborde conclude that it is very probable that the ingestion of radium salts would have the same effect.

Considering the well-known affinity of the skeleton for salts of calcium and strontium introduced into the organism, it is quite probable that salts of radium would also go, as in the above mentioned experiments, and be fixed on the skeleton.—*Chemical News.*

The long-eared bat alights and prepares for rest.

The Only Mammal Equipped by Nature for Flight

Curiosities of the Bat World

By Harold J. Shepstone

Getting his winged arms ready to inclose his ears.

Of all the more common animals about us the bat is probably the least well known to the average man. This is because of its nocturnal habits and the consequent difficulty in observing it. Indeed, all that most people seem to know about bats is that they fly at night and are "awful things to get into your hair." As a matter of fact, there is no authentic instance of a bat ever alighting upon a woman's hair, and they are no more in the habit of doing so than are humming birds.

The fact is, very little is known concerning the habits of bats, and much remains to be found out about them. The order comprises some 450 species, but it is safe to say that three fourths of them are known only by their dry skins and skulls. They exhibit differences in form that are fairly bewildering. They range all the way from the beautiful to the fantastic and hideous. The great majority, however, are useful to man in destroying insects which, without the aid of birds and beasts, would very soon overwhelm him. The harmful species are those which destroy fruit, and a few which suck the blood of domestic animals.

The bat has figured in folk-lore from the earliest times. Bats are supposed to have given the Latin poet Virgil the idea of harpies—creatures that had the faces of women and the wings and claws of birds. The Greeks had a story about the two daughters of a certain hero who, on account of their obstinacy, were changed by the gods into bats. The Saxons called the bat the "rere-mouse." The word comes from *hreran*, to move, and *mus*, a mouse—the mouse that moves the air with its wings. The word is now used only in heraldry as signifying a bat on a coat of arms. You may hear country people speak of the flitter-mouse, and the word has been used sometimes in poetry, as for instance:

"And giddy flitter-mice with leather wings."

The Chinese speak of the bat as the heavenly rat, the fairy-rat, the flying-rat, or the night swallow. Their ideas of the animal are very odd; they believe that it flies head downward because its brain is so heavy, and that it lives to a very great age because it has the habit of swallowing its breath. They also take the bat as their emblem of happiness. A symbol consisting of five bats is called *wee fuh*, or the "five happinesses" which everyone is supposed to desire; they are wealth, health, goodness, long life, and a peaceful death. In China, if you wish your guest good luck, a graceful way of doing so is to have five bats depicted on the bottom of his teacup.

The bat is not a bird, but a mammal, with almost as wide a departure from the ordinary, four-legged, land-going type as is a whale or manatee. Its hand reveals an extreme degree of what is called "specialization." For a mammal the arms are of unusual length. The bones of the fingers are enormously extended, and connected with hairless skin as flexible as India rubber, to form a wing for flight. This wing membrane is extended on up the arm to the body and the legs, and is continued between the legs and tail, where it forms a supporting parachute in flight. The thumb of a bat is very short and free, and its nail is developed as a hooked claw, by the aid of which the creature can comfortably climb about or support itself. The favorite position of a bat at rest is hanging by its feet, head downward.

One of the strangest characteristics about the bat is that it cannot fly from the ground. When it finds itself upon *terra firma* it crawls painfully to some wall or tree and, clambering up to a suitable elevation, launches itself into the air. Curiously enough, too, it accomplishes this climbing trick upside down, holding on with one of its hinder hooks while it reaches up and lays hold of the slightest inequality with the other. In this way it makes rapid progress and, flinging itself into the air, takes flight. Once upon the wing all awkwardness of the bat disappears as if by magic.

To be as "blind as a bat" is not to be blind at all, but rather to possess powers of vision that are uncommonly good in semi-darkness, or at night, and fairly good even in broad daylight. When disturbed at mid-day bats will fly to places of safety as briskly and as successfully as so many swallows. Their eyes are small, having the appearance of tiny black beads, and in this respect they are an exception to most night animals. They all possess teeth, but here they show a wide variation. The blood-sucking vampire bats of South America, for instance, have very large canine teeth with sharp, cutting edges, while even the molar teeth are formed with scissor edges, very much like the teeth of cats.

The bats have been divided into two natural suborders, insect-eating bats and fruit-eating bats. In the former there are five families, namely, leaf-nosed bats, free-tailed bats, common bats, vampires, and horseshoe bats. There is only one family of fruit-eating bats, namely, the flying foxes, so named on account of their having faces like a fox. This is the largest of all bats. Specimens have been found measuring as much as four feet from tip to tip of extended wings. They inhabit India, Ceylon, the Malay Archipelago and Eastern Australia. Some of the fruit growers of California are so apprehensive of this creature, and so fearful that they might be "introduced," that they have secured the passage of a law by which the importation of the flying-fox is prohibited so rigidly that not one specimen can be imported, even for exhibition in a zoological garden.

Each family, of course, has numerous varieties. There are over two hundred species of the common bat, some seventeen of which are found in the United States. Only three of these, however, are in any way common. By far the commonest is the beautiful little red bat, which appears in the early twilight, gliding on soft yet noiseless wings up and down the shaded streets and roads, and occasionally making a diversion into an open window or through a veranda, partly for business purposes and partly as an evidence of friendly regard. Then there is the gray bat, one of the largest and handsomest species inhabiting the northeastern United States and Canada. It has small ears, a head-and-body length of three inches, tail two inches, and is readily distinguished by its dark-brown hair tipped with silver white. Another interesting species is the big-eared bat of the south Atlantic States, whose ears are one half as long as the entire head and body. In this respect it resembles the long-eared bat of the Old World. In the whole history of life on the earth probably no animal has possessed proportionately larger ears than those of the long-eared bat. It is only occasionally seen in flight during daylight. Then it becomes a most curious object indeed, for during flight it is quite unlike any other creature of the air. Its huge ears are erected and lowered continually in a most extraordinary manner, and being almost as long as its body, give it a very striking effect when seen against the light.

The Great Bat or Noctule (Vesperugo noctula). This bat measured a little over 13 inches across its expanded "wings."

One ear is then carefully put away.

The members of the family of leaf-nosed bats have a strange appendage upon their noses in the form of thin leaves of naked skin that stand erect behind, or partly around the nostrils. It is supposed that this aids the creature is guiding its flight. The vampire bats of South America are the most gruesome-looking of all the bat family. Of these the javelin is certainly the most aggressive and most dreaded. It bites horses and cattle, usually on the shoulders, neck, or hindquarters, and makes a wound in the skin of sufficient depth to cause blood to flow freely, even after the bat has flown away. Some varieties, too, will attack human beings, biting them when asleep either upon the ears or feet. With its sharp-edged teeth the creature makes a very small round hole in the skin, and by means of mouth suction, which must be quite powerful, the blood is soon flowing freely. Fortunately, blood-poisoning is not an attendant evil of the vampire's bite, and the wound seldom becomes painful.

The sense of touch and hearing is undoubtedly very highly developed. Every nerve of body and membrane is a delicate instrument of touch, while the huge donkey-like ears of the long-eared bat make it quick to note the slightest sound. The organ of smell, apparently assisted in some species with the leaf-like flap over the nose, is also highely developed. From the results of observation it seems htat it depends more upon this sense, added to its quick sense of hearing, in the capture of its night-flying prey than upon any other. Probably the bat has a variety of methods for capturing the moths and other insects upon which it feeds, but it certainly curls its tail downward, and thus makes a sort of trawl-net of the membrane which connects tail and hind legs, and scoops up numbers of insects, which it eats at its leisure.

The bat goes into hibernation in the late autumn, coming out again in the early spring. Its hibernation is very complete. It is an astonishing fact, which has been scientifically proved, that respiration absolutely ceases. Such a state is almost unthinkable to a creature like man, who cannot survive the cessation of the action of his lungs for more than a minute or two at a time. Yet a bat which is in a state of hibernation can be placed under a receiver containing carbonic acid gas, and can be kept there for several hours without incurring the least harm. Yet, if the same bat were caught on some summer's night, and popped into the same vitiated poison, it would die instantly, just as a dog or cat does when placed in the lethal chamber.

Some people have never heard the squeak of a bat, even though they have seen scores of them flying about their heads. It was not because the thrill was not uttered, but because their auricular organs were not capable of appreciating it. The cry of a bat is certainly not pleasant, resembling somewhat the rubbing of two fine pieces of steel together. Bats are gregarious. As in the case of swallows, one seldom sees a single bat without immediately seeing others, while when asleep, and especially when hibernating, they often hang, not only upon the walls, but upon each other, in perfect masses and festoons, occasionally scores and even hundreds together. One of the earliest explorers of the Mammoth Cave of Kentucky was astounded at the spectacle of bats hanging in the greatest profusion and in all directions from the roof. To get an idea of their number he selected a space four and a half inches square, and on this small area he counted as many as forty. As the cave extends for 150 miles he reckoned that there must have been millions of bats that had retired there for their winter sleep.

The other ear follows and he is soon fast asleep.

A gentleman who visited one of the rock-cut tombs of the Lydian Desert found it tenanted by bats. They were so numerous that they swarmed over his person, while hundreds fluttered around him. Explorers of the pyramids of Egypt have had similar experiences; indeed, wherever there are caves, or crypts, or subterranean tunnels, or church towers they are haunted by bats.

These creatures of the night have often been tamed, and though one would instinctively somewhat shrink from making a pet of a bat, yet all who have ever kept them are unanimous in giving them an admirable character, saying that they will become so attached that they will fly out of the open window, hawk for insects all night, and be found in the morning hanging by the same window waiting to be taken in.

The Use of Oxygen in Blast-Furnace Practice*

By Gustave Trasenster

For some time past a Belgian company has been carrying out experiments on the use of oxygen in metallurgy, with special reference to blast-furnace practice. In order to obtain the oxygen required the company has had recourse to the air-liquefaction process, deeming that, in the present state of the science, this was the only process which could be regarded as capable of yielding in commercial quantities and sufficiently cheap, the large amounts of oxygen which it was necessary to employ. The system adopted at Ougrée for the liquefaction of air and its separation into its elements, is that of Georges Claude, of Paris. Without entering into a detailed description of the process, a description which those interested in the subject can easily obtain elsewhere, a few brief explanations relating thereto will be given here. As is well known, the liquefaction of air by the Georges Claude process is obtained by means of great cold resulting from expansion on doing work outside. This expansion, incomparably more efficacious than any other, is obtained with the greatest ease by driving, by means of compressed air, an expansion vessel; simply a piston working in a cylinder, very much like an ordinary steam piston. At Ougrée the pressure required for the compressed air is 15 atmospheres. This method of expansion, in spite of its efficaciousness, is incapable of refrigerating the air in a temperature sufficiently low for its liquefaction in a single stroke; and it is by means of what may be described as a temperature transformer that the air, escaping from the expansion cylinder by a tube concentric to that by which it is admitted, is able rapidly to attain the temperature of liquefaction.

The liquid air having been obtained, advantage is taken in the process described of the difference between the boiling points of liquid oxygen and liquid nitrogen to separate the two elements. The boiling point of oxygen is —180 deg. Cent., and that of nitrogen —195 deg. Cent. This separation, however, necessitates boiling the mixture, and this is effected very easily in a vaporizer; the gases resulting from the ebullition rise in a receiver, the sides of which are sprayed by intensely cold liquids, mixtures of more or less liquid oxygen and nitrogen, which effect condensation and, as a result, the almost complete separation of the oxygen in the ascending gases. Thanks to this arrangement, the apparatus allows of pure gaseous oxygen being obtained on the one hand, and, on the other, equally pure nitrogen containing, at most, a few hundredths of oxygen. The apparatus works almost automatically.

The Oxygen Plant at Ougrée.—This plant is capable of making 600 cubic meters of oxygen per hour. It is composed of three absolutely similar liquid-air units, each unit yielding 200 cubic meters of oxygen hourly.

A unit consists of:

1. A compressor, capable of drawing in 1,200 cubic meters of air per hour, and of compressing it at a pressure of 15 atmospheres. This compressor is belt-driven from an electric motor.

2. A liquid-air machine and tower, containing all the fittings and appliances necessary for the liquefaction and separation of the air into oxygen and nitrogen.

3. Two decarbonizing towers. It is, as a matter of fact, of prime necessity that the air drawn in by the compressors and sent into the liquid-air machine should have every trace of carbon dioxide it contains removed. With this object the air is made to pass through two towers containing brick chequer work, which is sprinkled with a solution containing soda.

4. A battery of desiccators intended to remove any moisture contained in the air. This battery is interpolated between the compressors and the liquid-air machine, and therefore receives the air under pressure. The desiccation is effected by means of calcium chloride.

The operations are of the simplest description, and the staff is very small. The manufacture of oxygen from liquid-air has become a thoroughly practical and business operation; and thanks to certain improvements with which the Ougrée machinery is equipped, it has been possible to secure continuous working.

The energy required is only very slightly over one horse-power for every cubic meter of oxygen per hour. It is not possible, however, to base calculations on this figure, which, if anything, is rather too high, as, for a permanent installation, machines of larger capacity than 200 cubic meters of oxygen per hour would be used. The power absorbed by a cubic meter of oxygen would be less the larger the machines, and the Liquid-Air Company are at present engaged in making machines to produce 1,000 cubic meters of oxygen per hour. In these circumstances, and with the further improvements which will be made, it may even now be prophesied that with such machines of 1,000 cubic meters capacity of oxygen per hour, the power consumption per cubic meter will fall to two thirds of a horse-power.

Experiments of the Ougrée Company.—Unfortunately no definite results can as yet be given as to the experiments it is intended to make. Certainly some months ago a preliminary trial was carried out, but its duration was too short to justify conclusions being drawn. Owing to a set of circumstances quite distinct from the ultimate object of the experiments, this preliminary trial had to be discontinued, but it will shortly be resumed. Proposed experiments relate to two problems:

1. The first series of experiments will relate simply and solely to enriching the blast delivered to one of the company's existing blast-furnaces, by oxygen, that is to say, mixing with the blast for this blast-furnace the 600 cubic meters of oxygen available. The percentage of oxygen in the blast will be raised by these means from 20.8 to about 23 per cent. The problem to be solved is whether this degree of enrichment is sufficient to cause the anticipated phenomena to manifest themselves sufficiently distinctly.

2. Other experiments will be carried out in a small blast-furnace which has been built, and in which working will be carried out with very high percentages of oxygen, and even with pure oxygen. In the latter instance, should the need of so doing be felt, recourse will be had to the Oscar Loiseau process, and the intense heat will be reduced by introducing some of the waste gases at the hearth, so that, in any case, the reducing atmosphere in the furnace will be free from nitrogen.

With regard to the results that may be expected, but without too rigidly anticipating effects or entering into theoretical speculations, it may be said that a reduced consumption of fuel, greater speed in the working of the furnace, and increased purity in the products, may be looked for. So far as the power consumption in the manufacture of oxygen is concerned, the more highly the blast is super-oxygenized the smaller will be the volume it will be necessary to heat. On the other hand, although only actual experiment can decide the point, it may be necessary to heat the blast to a lesser degree. There would, therefore, be a certain amount of waste gas available. If it be found possible to work with pure oxygen, it will not be necessary to heat the blast, in which case the gases available will supply considerably more motive-power than will be required for the production of the oxygen. To this must be added that enormous quantities of nitrogen will be available, the utilization of which will more than defray the expenses involved in the manufacture of the oxygen.

*Paper read before the Iron and Steel Institute at Brussels, September 2nd, 1913.

Quelles Sont les Dix Plus Grandes Inventions de Notre Temps et Comment?

Scientific American Prize Contest : Essay Which Received Honorable Mention

Par "Nicolas" (Emile Stoop, St. Nicolaas, Waas, Belgique)

The circulation of the Scientific American and Supplement is international. Among the essays honorably mentioned by the judges awarding the prizes in the "Ten Greatest Inventions" contest, is the one reproduced on this page in its original form, in French. In preparing these essays for publication, the editors have felt that they must waive their accustomed privilege of amending the author's manuscript wherever their literary taste does not quite agree, in minor points, with that of the writer. For this reason the essay here published has not been translated, but is presented in its original form.—EDITOR.

Si nos pères d'il y a cinquante ans devaient ressusciter de leur tombe et jeter un coup d'œil sur le monde actuel, ils seraient tout ébahis à la vue des changements qui se sont réalisés dans notre civilisation. Les automobiles, les trams électriques, les cinématographes, les aéroplanes, les dirigeables "Zeppelin," la télégraphie sans fil, la radioscopie, la machine pour la liquéfaction de l'air, la lampe à incandescence et le phonographe sont tant d'inventions dont l'idée a occupé longtemps l'esprit humain et qui ont trouvé ces 25 dernières années ou leur solution ou leur application soit industrielle soit commerciale. Toutes peuvent être considérées comme les plus importantes qui se sont accomplies pendant ce laps de temps à cause:

1°de la perturbation qu'elles ont amenée dans la société; 2°des changements brusques qu'elles ont apportés dans la façon de vivre, dans les manières et les habitudes des hommes;

3°des services éminents qu'elles rendent de nos jours; 4°du développement qu'elles ont amené dans les sciences, le commerce et l'industrie.

Pour mieux nous en rendre compte, considérons chaque invention à son tour, et isolément.

L'automobile est une voiture qui marche à l'aide d'un moteur propulsif à vapeur, à l'électricité, à air comprimé, à gaz, etc. Bien que le premier date de 1765 et ait été amélioré graduellement, il faut cependant arriver jusqu'en 1889 pour trouver un type d'automobile vraiment pratique et qui présentait sur ces devanciers une véritable supériorité. Ce véhicule, dû à l'ingénieur Serpollet, utilisait la découverte que venait de faire cet inventeur, savoir, la chaudière à vaporisation instantanée basée sur l'emploi de tubes à section très réduite et dans laquelle on obtint rapidement de la vapeur à haute pression. D'autres inventeurs imaginaient vers la même époque le moteur à explosion pas précisément dans le but de l'appliquer aux automobiles, mais qui devait être par la suite d'un emploi si fréquent dans cette branche de la mécanique. Inventé par l'officier français Cugnot, l'automobile a progressé rapidement dans la voie de l'usage par les découvertes de l'ingénieur Serpollet, des inventeurs du moteur à explosion et du savant Planté par l'introduction du moteur électrique alimenté par des accumulateurs. A voir le trafic qui s'effectue au moyen des automobiles, l'on peut dire hardiment que de nos jours, l'on ne pourrait plus se passer de ce moyen de locomotion rapide qui réalise au plus haut degré le proverbe anglais bien connu: "Time is money." Non seulement, il procure au richard la jouissance de pouvoir se déplacer aisément, mais il rend au commerce de grands services en transportant toutes sortes de marchandises. Plusieurs commerçants se verraient même fortement lésés dans leurs affaires s'ils ne disposaient pas de ce moyen de transport. Comme manifestation du luxe et à raison de sa vitesse, l'automobile a fait ces dernières années dans nos villes une concurrence acharnée à la voiture et au fiacre qui ne sont plus de notre temps et a remporté victorieusement le premier rang. C'est donc en réalité une invention qui s'est tellement vulgarisée qu'elle peut être considérée comme universelle.

Les tramways électriques se rattachent à l'automobile par l'identité de services rendus dans les villes. C'est une voie ferrée établie sur une route ordinaire, une rue quelconque, au moyen de rails sans saillie, sur lesquels circulent des voitures à traction mécanique. Bien que l'idée de tramways et la première installation à New York d'une ligne à traction animale date de 1842, il faut remonter cependant à l'époque où les transformatrices ont réussi à ramener les voltages énormes nécessaires de 10.000, 20.000 et même 40.000 volts à 110, 220 et quelquefois 500 volts, pour voir se vulgariser l'établissement des tramways électriques. Dans les grandes villes, ils sont aussi indispensables à la communication que les rues mêmes. Si le besoin n'y avait pourvu, la vie en ville serait quasi-impossible ou du moins excessivement alourdie à cause de la perte de temps occasionnée par chaque déplacement. Les tramways à traction animale conçus par le français Loubat, qui en a fait la première installation, ont été très influencés par l'américain Train et se sont vu compléter lors de l'invention des transformatrices. C est à partir de ce moment qu'ils ont été établis dans toutes les villes.

Sur le troisième rang se place l'invention de l'aéroplane qui est une machine composée de surfaces planes ou presque planes, immobiles, légèrement inclinées sur l'horizon et se soutenant en l'air sans être plus légères que lui, par la vitesse acquise et en vertu de la pression du vent sur les surfaces. Sans remonter aux légendes antiques, on peut dire que les premiers essais datent du XV^{e} siècle, bien que les résultats aient été insignifiants. Ce n'est que ces dernières années qu'ils ont jeté la consternation mêlée d'admiration sur le monde entier. Cette invention consacre un principe nouveau et répond à la satisfaction d'un goût de l'homme, qui, de tout temps, a cherché par de nombreuses tentatives à se diriger dans les airs comme l'oiseau. L'aviation contribue en outre chaque jour au progrès dans la météorologie en permettant l'étude des hautes régions de l'atmosphère. Bien que cette invention ait coûté la vie à bon nombre de personnes et n'ait jusqu'à présent apporté aucune part à la richesse ou au bien être général, elle a été très appréciée pendant la guerre tripolitaine à cause des services importants rendus pendant cette campagne. Qu'elle soit appelée à un grand avenir ne laisse aucun doute quand on prend en considération l'empressement fébrile et l'ardeur avec lesquels les grandes puissances de l'Europe rivalisent entre elles pour s'accaparer du monopole des systèmes les plus praticables. Les principaux essais qui ont eu chacun pour effet des développements et amèliorations ont été faits par l'ingénieur Hiram Maxim en 1889, par Langley de 1893 à 1896, Tatin et Richet de 1890 à 1897, Santos Dumont en 1906, Ferber, Esnault-Pelterie, Delagrange, Frères Wright, Blériot, Farman, etc. en 1908, et se continuent encore journellement.

Nulle invention n'a rencontré plus de controverse et d'incrédulité et malgré cela n'a joui en même temps d'autant de confiance de la part de l'inventeur et de ses partisans que les ballons dirigeables du système Zeppelin. L'aeronautique, commencée par les frères Montgolfier d'Annonay, qui tentèrent leur première expérience le 5 juin 1783, n'a progressé que très lentement. Les plus belles pages de son histoire seront certes celles qui traitent de la construction et des premières épreuves du dirigeable "Zeppelin" en 1906. Celles-ci ont été la réponse éloquente à un grand nombre de savants qui regardaient les entreprises du Comte Zeppelin comme une utopie. En effet, sa tenacité avait à vaincre des difficultés innombrables qui en théorie semblaient insurmontables. Ces dirigeables disait-on, à raison de leur dimensions énormes ont à vaincre une résistance fabuleuse de l'air, laquelle se multiplie à l'infini avec l'augmentation de la vitesse, ce qui exige une force motrice colossale. Celle-ci à son tour nécessite de nouveaux moteurs, de nouvelles machines, qui en tout cas ont un poids supérieur à celui que sait supporter le ballon. L'agrandissement du dirigeable ne peut être préconisé comme remède dans cet état de choses puisque la résistance de l'air augmente proportionnellement à la grandeur. Au point de vue militaire, la possession de ce système de ballons assure à une nation comme l'Empire Allemand une supériorité évidente sur ses adversaires. Les dirigeables Zeppelin devançant en vitesse les plus rapides express, obéissant minutieusement aux moindres mouvements du gouvernail, munis de mitrailleuses et de canons placés sur ses plates-formes, its sont en mesure d'atteindre en une nuit la capitale du pays ennemi, comme Paris par exemple, et d'y semer l'effroi et la désolation par une pluie de bombes et de détruire tous les aéroplanes de l'adversaire qui voltigent en l'air. Honneur donc au courageux Comte Zeppelin qui n'a pas hésité à employer sa fortune à la réalisation de ses projets ainsi qu'au Kaiser et au peuple allemand qui par leurs souscriptions en ont fait une oeuvre nationale.

La télégraphie sans fil basée sur le principe comme quoi les courants induits se propagent à de grandes distances, comme la lumière, le son, etc., par des ondes concentriques, a été rendue possible par suite de l'invention du cohéreur dû au physicien français Edouard Branly. Ces ondes sont lancées dans l'espace au poste transmetteur au moyen d'un conducteur métallique formé d'un câble en fil de cuivre supporté par un mât de grande hauteur appelé antenne. Au poste récepteur une disposition analogue amène les ondes à un récepteur capable de traduire leur action en effets utilisables. Cette invention, dont on ne sait dès à présent prévoir les suites, est appelée à un grand avenir. Grâce aux savants Branly et Marconi, elle rend déjà d'importants services dans la navigation.

Nulle invention n'a eu autant de succès que le cinématographe. Inventé par les frères Lumière, il s'est introduit jusque dans les plus petits villages. C'est un appareil chronophotographique réversible qui inscrit d'abord sur une première bande pelliculaire la série des attitudes à raison de 15 par seconde; cette bande d'images négatives est utilisée dans l'appareil même à l'obtention d'une nouvelle bande qui portera cette fois des images positives. En substituant à la chambre noire qui, dans la première opération était adjointe au cinématographe, une lanterne à projections, et faisant dérouler à nouveau la bande à la même vitesse, on projette sur l'écran l'image animée qui constitue la scène primitive et l'observateur a la sensation très nette d'un mouvement continu. Le cinématographe est une de ces inventions qui à raison de leur succès colossale peuvent ou bien répandre le vice d'une façon irréparable ou bien faire du bien d'une manière illimitée. Conçu de la bonne façon c'est à dire en évitant dans les représentations tout ce qui peut blesser les mœurs ou le bon goût, il doit être consédéré comme un bienfait. Les films de voyages, de sites pittoresques, de monuments, et de scènes innocentes ne peuvent qu'augmenter la connaissance de la géographie, des sciences, des arts, du bon goût, du beau, en un mot de l'esthétique. Les frères Pathé, qui font beaucoup d'efforts pour satisfaire une clientèle difficile, sont en Europe les principaux fabricants de films.

La radioscopie et la radiographie ou l'examen et la photographie d'un objet quelconque doivent surtout leur développement au physicien Röntgen, l'inventeur des rayons X, lesquels permettent de photographier à travers des corps opaques. Cette science a été poursuivie et complétée par le savant Becquerel, qui par ses expériences a prouvé que certains corps possèdent la propriété d'émettre des radiations susceptibles d'impressionner la plaque photographique et d'exciter la phosphorescence. M. et Mme. Curie l'ont complétée et ont découvert en 1898 un élément nouveau savoir le radium, qui jouit entre d'autres propriétés de celle d'émettre des rayons lumineux d'une intensité stupéfiante.* La radiographie s'emploie de plus en plus en médecine et chirurgie. Elle décèle les calculs du rein, les lésions osseuses, les fractures des os; elle permet dans ce dernier cas de voir à travers les appareils plâtrés si les réductions sont bien faites. La radioscopie, de son côté, est surtout utile pour le diagnostic des maladies de l'appareil respiratoire et de certaines affections abdominales.

La liquéfaction de l'air est restée du domaine du laboratoire jusqu'en 1895, époque à laquelle Linde de Munich a inventé une machine industielle qui a permis d'obtenir l'air liquide par quantités notables. Cest à Faraday que l'on doit les premières recherches systématiques sur la liquéfaction des gaz. L'air liquide, qui bout entre −182° et −192°, à cause de ses applications multiples dans l'industrie est devenu d'une importance capitale et d'une grande utilité dans cette branche.

La lampe à incandescence est une lampe électrique dans laquelle la lumière ne provient que de l'incandescence, dans un espace vide d'air, d'un conducteur tenu sous l'action d'un courant qui le traverse. La lampe d'Edison qui en est le prototype se compose d'un filament de charbon porté à l'incandescence dans une ampoule de verre où l'on a fait le vide. D'autres types basés sur le même principe sont les lampes à filament de platine, de tantale et enfin celles à vapeurs de mercure, fondées sur la fluorescence des vapeurs de mercure dans le vide au passage d'un courant électrique. Insister sur la vulgarisation et les services rendus ces dernières années par les lampes à incandescence est inutile attendu

* Exception must be taken to this statement.—ED.

que l'électricité est placée jusque dans les moindres villages.

Enfin arrive le phonographe qui est un appareil qui enregistre et reproduit les sons. Imaginé en 1877 par Edison, il permet aujourd' hui grâce à de nombreux perfectionnements, qui ont augmenté son débit dans le commerce d'une façon considérable, de reproduire parfaitement la parole, le chant, le timbre même des instruments. Il suffit de placer dans le sillon de profondeur variable, tracé sur le cylindre en cire durcie ou le disque en ébonite, l'aiguille du reproducteur et de faire tourner le cylindre ou le disque de la même allure que pendant l'enregistrement, et les vibrations de la lame vibrante du reproducteur renouvelleront exactement celles du diaphragme du récepteur. La réunion des mécanismes synchrones d'un cinématographe et d'un phonographe a permis la construction d'un instrument dans lequel les mouvements du cinématographe et les sons du phonographe sont synchroniquement combinés. Quant à son utilité, chacun se rappelle les heures délicieuses passées sous le charme de sa musique.

. . . .

Après avoir passé en revue ces inventions et examiné leurs avantages, nous ressentons une sincère reconnaissance et une vive admiration envers ces pionniers du progrès et de la lumière, qui par leur génie, leur courage et la persévérance sont arrivés à la réalisation de leurs projets. L'étude de ces inventions conduit à la conclusion, qui ne saurait être sujette à critique, que tout progrès doit être acquis et mérité par de longs efforts personnels. Le seul témoignage de gratitude et la seule récompense que l'humanité peut offrir à ces vaillants, c'est l'immortalité et le classement parmi les hommes illustres qui par leurs faits et actes ont honoré et leurs noms, et leurs mémoires et la nation même à laquelle ils ont appartenu ou appartiennent.

A Wood That Never Rots

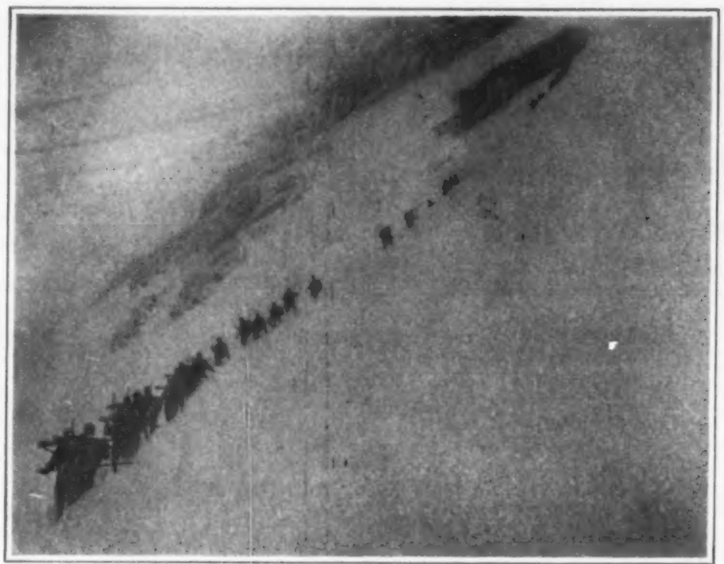
Engineers have often to deplore the rotting of railway sleepers, of piles, and of wood used to support galleries, in the building of ships, etc. Engineers, chemists, physicists, biologists, doctors, who, for the construction of diverse apparatus, may require a wood possessing a maximum resistance to the causes of destruction, particularly humidity, are interested in this important question of the unputrescibility of wood. The ideal would be to find a wood of a character susceptible of resisting putrefaction naturally. Now it appears from recent researches that the wood of the mangrove tree may be considered as absolutely unputrescible. Numerous samples of mangrove wood (*Rhizophora racemosa*) sent from French Guinea were, in 1909, placed at Collonges (Côte d'Or) in a soaking pit in the depot of sleepers of the Paris-Lyons-Mediterranean Railway Company. The samples were surrounded with all the elements susceptible of producing the decomposition and rotting of the wood in a minimum of time. In spite of these precautions the samples have up till now remained in an excellent state, and show no signs of the least alteration. Why is putrefaction unable to attack the wood of the mangrove? From whence do the particular and excellent qualities of this too little known wood proceed? It is first of all to be remarked that the grain of the mangrove wood is very close; for this reason it opposes a barrier to the invasion of water, by a quasi-mechanical action. To get an idea of the importance of this fact, it suffices to examine comparatively the densities of the woods of the mangrove, oak, and fir. The first is about 110, the second 70, and the third 40. Moreover, mangrove wood has an amount of tannin quite sufficient to prevent the invasion of insects and to prevent the multiplication of germs, damp, mould, and all various micro-organisms which constitute the flora of the woods of different climates. The wood of the mangrove marvelously resists flexion; its resistance is double that of oak, quadruple that of fir; nevertheless, it is not at all brittle. To crushing either at the end or across the fibers it offers a resistance double that of oak and three times that of fir. It resists admirably the efforts of wringing or twisting, far better than the two other woods mentioned, to which it is far superior in suppleness. With these qualities just enumerated it is easily worked; it is as easily sawn as the oak. From the few preceding remarks we may conclude that the wood of the mangrove merits employment on a large scale and for purposes both numerous and varied. Henceforth its use appears to be indicated for the construction of the posts of electric lines on account of its unputrescibility, its resistance, and its suppleness. Its resistance to putrefaction and to crushing render it precious for the construction of sleepers of narrow railways. Its use would be advantageous compared with other woods for the special wood-work of mines, where it would offer all the qualities required by hygiene. And, besides, everyone will find good use for a wood that never rots.—*Chemical News*.

The New Italian Airship.—Very much like the Veeh airship recently described in these columns, is the new "Citta di Milano," designed by Forlanini. She is 236 feet long and 59 feet broad. She has two motors of 100 horse-power each, capable of driving her at a speed of 45 miles an hour. Her propellers have a diameter of 13.7 feet and a speed of 260 revolutions per minute. The car is made to adhere to the envelope instead of being suspended by the usual rigging.

List of Ships of the United States Navy Under Construction August 1, 1913

Name.	Displacement. (tons).	Type.	Hull.	I. H. P.	Propulsion.	Guns (main battery).	Place where building.
New York	27,000	Battleship	S.	32,000	T. S.	31	Navy yard, New York.
Texas	27,000	"	S.	32,000	T. S.	31	Newport News Ship Building Co.
Nevada	*a*27,500	"	S.	*a*24,800	T. S.	31	Fore River Ship Building Co., Quincy, Mass.
Oklahoma	*a*27,500	"	S.	*a*24,800	T. S.	31	New York Ship Building Co., Camden, N. J.
Pennsylvania	31,400	"	S.	*a*31,500	4 screws	34	Newport News Ship Building Co.
Battleship No. 39	31,400	"	S.	*a*31,500	4 screws	34	Navy Yard, New York.
Cassin	1,020	Destroyer	S.	16,000	T. S.	4	Bath Iron Works, Bath, Me.
Cummings	1,020	"	S.	16,000	T. S.	4	Do.
Downes	1,072	"	S.	16,000	T. S.	4	New York Ship Building Co , Camden, N. J.
Duncan	1,014	"	S.	16,000	T. S.	4	Fore River Ship Building Co., Quincy, Mass.
Aylwin	1,036	"	S.	16,000	T. S.	4	Wm. Cramp & Sons, Philadelphia.
Parker	1,036	"	S.	16,000	T. S.	4	Do.
Benham	1,036	"	S.	16,000	T. S.	4	Do.
Balch	1,036	"	S.	16,000	T. S.	4	Do.
O'Brien	1,050	"	S.	17,000	T. S.	4	Do.
Nicholson	1,050	"	S.	17,000	T. S.	4	Do.
Winslow	1,050	"	S.	17,000	T. S.	4	Do.
McDougal	1,020	"	S.	17,000	T. S.	4	Bath Iron Works, Bath, Me.
Cushing	1,050	"	S.	17,000	T. S.	4	Fore River Ship Building Co.
Ericsson	1,090	"	S.	17,000	T. S.	4	New York Ship Building Co.
Nereus	19,000	Fuel Ship	S.				Newport News Ship Building Co.
Kanawha	14,500	"	S.	*a*5,200	T. S.		Navy Yard, Mare Island.
Maumee	14,500	"	S.		T. S.		Do.
Palos		Gunboat	S.				Do.
Sacramento		"					Wm. Cramp & Sons, Philadelphia.
Monocacy		"					Navy Yard, Mare Island.
Fulton		Submarine tender.					New London S. & E. Building Co.
G–2		Submarine					Newport News Ship Building Co.
G–3		"					Lake Torpedo Boat Co., Bridgeport, Conn.
G–4		"					Wm. Cramp & Sons, Philadelphia.
H–1		"					Union Iron Works, San Francisco.
H–2		"					Do.
H–3		"					Seattle Construction & Dry Dock Co.
K–1		"					Fore River Ship Building Co., Quincy, Mass.
K–2		"					Do.
K–3		"					Union Iron Works, San Francisco.
K–4		"					Seattle Construction & Dry Dock Co.
K–5		"					Fore River Ship Building Co , Quincy, Mass.
K–6		"					Do.
K–7		"					Union Iron Works, San Francisco.
K–8		"					Do.
L–1		"					Fore River Ship Building Co.
L–2		"					Do.
L–3		"					Do.
L–4		"					Do.
L–5		"					Lake Torpedo Boat Co., Bridgeport, Conn.
L–6		"					Craig Ship Building Co., Long Beach, Cal.
L–7		"					Do.
M–1		"					Fore River Ship Building Co.
Melville	7,150	Destroyer Tender.	S.		1	8	New York Ship Building Co.
Bushnell	3,580	Submarine Tender	S.		1	4	Seattle Construction & Dry Dock Co.

*a*Estimated



Swiss army maneuvers on Jungfrau-joch, 11,090 feet above sea level. The station Jungfrau-joch of the famous railroad leading into this region of eternal ice and snow is seen at the top of the picture to the left.

A Wonderful Glacier March by Swiss Soldiers

Three Miles of Roped Troops

By Thomas B. Donovan

THE mountain regiments of the Swiss army are renowned for their skill and daring, but their latest exploit has excited wonder in the highest military circles, and even criticism on account of the risks undertaken. The Swiss maneuvers this autumn took place in the neighborhood of the Furka and Grimsel Passes, and the various regiments engaged had been approaching this district by various routes. Four companies of a Bernese Overland mountain regiment, consisting of 550 men, were told off to proceed to their destination by way of Jungfrau-joch (over 11,000 feet above sea-level) and the Great Aletsch Glacier, which is fifteen miles long and full of yawning crevasses.

On the first day the troops marched as far as Wengen, the Little Scheidegg Pass, and the Eiger Glacier, various detachments spending the night at these places. In the early hours of the following morning the transport of the 550 men to the tremendous ice and snow-clad ridge of the Jungfrau-joch began. The services of the Jungfrau Railway, which runs to this, the highest station in Europe, through a unique mountain tunnel, were requisitioned for this purpose. Before dawn all the troops were assembled in the small chamber from which one emerges on to the Joch, and the work of roping up began. Outside the wind blew furiously, there was a dense mist, and anyone venturing outside was immediately covered with white by the driving snow storm.

The weather was such that no guides would have undertaken the responsibility of conducting tourists along Europe's greatest glacier. The commanding officer, however, was inexorable, and with the first gleam of dawn through the mist the order to march was given. Preceded by experienced guides and an officer who carried a compass for the purpose of finding the route, it being impossible to see for more than a few dozen yards, the soldiers began their descent on to the glacier. A steep snow slope in which they sank to the thighs had to be negotiated before even the level of the glacier was reached.

Roped together in groups of five, and carrying rifles and alpenstocks in addition to a kit weighing seventy pounds, the long line of soldier-alpinists cautiously descended on to the glacier, and were in a few minutes swallowed up in the mist and blinding snow. Passing out in Indian file, it required two hours and a half for the four companies to reach the glacier, and a column three miles in length was formed. From time to time the mist rose a little and the watchers were vouchsafed the impressive sight of an endless line of black spots extending away into the white distance in sinuous snake-like fashion.

Progress along the glacier in these conditions, with the surface covered with a layer of fresh snow three feet in depth and every landmark obscured, was necessarily slow, and it was late in the afternoon before the Eggishorn, at the lower end of the glacier, was reached. Not a man fell out, and the troops reached their quarters on the alpine pastures beyond late in the evening, but in excellent spirits, many detachments singing. Such are the soldiers who have to be reckoned with by any possible military invader of the difficult country of Switzerland at the present time.

Report on Trials of a 100 Brake Horse-Power Marine Oil Engine

A Craft Designed for Inland Navigation

AN account of some recent tests of a 100 horse-power Junkers marine engine, of a type specially developed for the purposes of inland navigation, should prove of interest to many of our readers.

The advantages of the Junkers engine for inland navigation work, as compared with four-cycle and other two-cycle engines, are claimed to be as follows:

(a) Low weight, therefore shallow draught.

(b) Simple design, therefore simple attendance, which is of importance respecting the incompetent personnel often found on rivers and canals.

(c) Absence of certain parts which are frequently the cause of breakdowns, e. g., scavenging valves, exhaust valves and cylinder covers.

(d) Good balancing and light load on main bearings, therefore minimum wear and no overheating.

(e) Low fuel consumption, therefore low running costs.

(f) Small initial cost.

The engine was ordered on the 21st of February, 1913, the drawings were prepared in the drawing offices of Prof. Junkers in Aachen, and the engine was running on the test bed on June 6th.

DESCRIPTION OF THE ENGINE.

The engine has an output of 100 brake horse-power at 300 revolutions per minute. The two working cylinders and the scavenging pump are supported on and connected by a continuous scavenging air receiver. Both cylinders exhaust into one exhaust box, arranged horizontally at the rear of the cylinders. The scavenging air is delivered at a pressure of 2.2 to 2.9 pounds per square inch. The scavenge pump is driven directly off the crank shaft by a crank and connecting rod. Compressed air for the injection of the fuel oil and for starting the engine, is supplied by a simple acting three-stage compressor, the second stage of which is placed on top of the scavenge pump, the first and third stages being arranged at the rear of the scavenge pump.

Each cylinder is fitted with a fuel valve, a starting valve and a safety valve.

The two fuel valves are actuated by a cam shaft running horizontally along the top of a scavenging air receiver and connected by gearing to the crank shaft. The cam shaft has been placed so close to the fuel valves that a single light lever suffices to make the connection between the cam and the fuel valve needle. The inertia effect is thus reduced to a minimum and smooth, reliable working is the result. The arrangement can be adjusted with the greatest precision while the engine is running.

The starting gear is provided with an arrangement which positively prevents any fuel from entering the cylinders while the engine is starting up on compressed air.

The fuel pump is fixed to the scavenging air receiver at the flywheel end. It is driven by means of a crank in the vertical shaft connecting the cam shaft to the crank shaft. By means of a double lever, both pistons are driven off the same crank. The lever also works the rods of the suction valves.

The governing of the fuel supply to the requirements of the load is effected by varying the length of time that the suction valve is open during the pressure stroke of the fuel pump. The speed of the engine can be controlled independently of the governor, directly from the running platform or the bridge, by varying the lift of the suction valve.

Seven pressure gages are arranged on the front of the scavenging air receiver. Two of these are connected to the starting compressed air cylinders and two to the compressor receivers, the others register the pressure of the injection air, scavenging air and cooling water, respectively.

At the front end of the engine are arranged a circulating pump and a bilge pump, both directly driven by the main engine.

STARTING THE ENGINE.

After having made certain that the fuel supply pipe is filled with oil up to the fuel valves, also that the valves connecting the compressed air cylinders to the starting air-line are open, the only movement required to start the engine is to push over the starting lever to the "starting" position, thus admitting compressed air to the cylinders, and after a moment, usually after two or three revlutions, the starting lever is returned to the "running" position and the engine continues to run normally on oil. Thus, the whole operation of starting consists in moving a single lever once forward and back again.

THE TRIALS.

The first trials were for the purpose of adjustment and to test the various parts. All parts ran so well that after the usual adjustments had been made and

after the engine had been tried running light, a 24-hour trial could be held on July 1st; this was accomplished without any stoppage of any kind. The compressor worked satisfactorily, the fuel injection valves remained perfectly clean and all bearings remained at uniformly low temperature.

Further trials were made with the object of precise adjustment of the fuel valves, in order to obtain the most complete combustion possible.

The acceptance trials required by the purchasers, were run on the 11th to 13th of July by Prof. Laas and Prof. Romberg of Technical High School, Charlottenburg, on the test bed at Dahlbruch. A 72-hour continuous trial was stipulated. The engine was started up at 8 o'clock on the morning of Friday, July 11th, and ran without stoppage, except for a very short time in consequence of a necessary alteration to the testing brake, until 8 o'clock in the evening of July 13th, that is to say, 60 hours altogether. The purchaser's agents were so satisfied with the behavior of the engine that they did not require it to run during the last night.

During the whole of the continuous trial, the engine ran quietly and evenly, without any mishap whatsoever, the mean speed being 304 revolutions per minute. A sudden drop from full load to no load produced no rise of speed worth mentioning. The temperature of all bearings remained normal and nowhere was there any sign of overheating. There was no knocking or any other irregular noise in any of the working or pump cylinders, nor any chattering of the valves in the scavenge pump or compressor. Practically the only noise that could be heard was that of the air in the suction pipe. The scavenge pump worked with a comparatively low pressure of 0.2 atmospheres (= 2.9 pounds per square inch) and at this pressure very good scavenging was obtained. The exhaust was practically invisible.

During the trial, two hours were run at 10 per cent overload, which was carried by the machine in a perfectly satisfactorily manner.

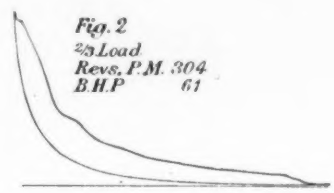
MANEUVERING TRIALS.

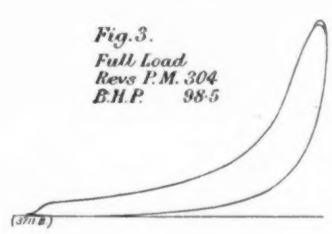
A compressed air-cylinder of 125 liters (= 4.4 cubic feet) capacity, filled with air of 60 atmospheres (= 880 pounds per square inch) pressure was used. The engine was run up to full speed and full load from rest ten times. The pressure in the air flasks had sunk to about 40 atmospheres (= 590 pounds per square inch) only. The engine started with exceptional ease and certainty.

After the conclusion of the trials, on Sunday, the 13th of July, at 7 o'clock in the evening, the crank chamber was opened in order to examine the crank pins and bearings. All bearings were found to be at a normal working temperature.

INSPECTION.

During the following night all moving parts, pistons, main bearings, scavenging pump and compressor valves, and circulating pump valves, were dismantled and carefully inspected on Monday morning the 14th of July. Everything was found to be in a satisfactory condition.





Since the hull of the boat, for which the engine is intended, was not then complete, the engine remained on the test bed several days longer. During this time further trials were made with various types of atomizers and injection nozzles, in order to reduce still further the consumption of fuel and injection air. The mean fuel consumption was 185 grammes (= 0.407 pounds) per brake horse-power hour at the normal load of a 100 brake horse-power, a very low figure. The maximum output obtained was about 120 brake horse-power.

Figs. 2 and 3 show some of the indicator diagrams taken during the official acceptance trials.

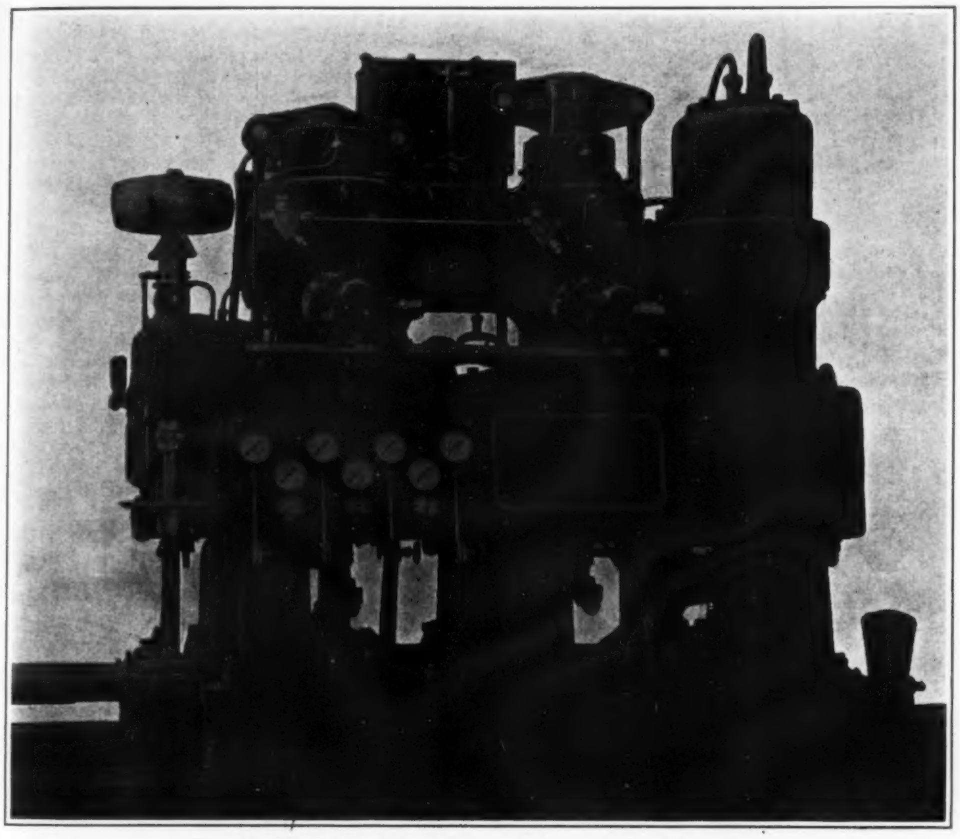


Fig. 1.—One hundred horse-power Junkers marine oil engine.

Lubrication With Oils and With Colloidal Graphite*

High Economic Efficiency and Remarkable Durability of a Graphoid Surface

By Charles F. Mabery

In a paper[1] published three years ago, an account was given of some results on the comparative efficiency in lubrication of oil lubricants, and oils carrying colloidal[2] graphite. It appeared in all the tests therein described that a lower coefficient of friction was given by the use of graphite than by the use of oils alone, that oils supported a much greater pressure with the aid of graphite, and especially that the graphite film was capable of sustaining the friction of a heavy pressure for a long period after the supply of lubricant was shut off. Much attention has since been given to various features of lubrication with colloidal graphite, especially in attempts to ascertain the actual economy of its use in replacing oil lubricants. The observations to be described in this paper present high economic efficiency and a remarkable durability of a graphoid surface.

It has long been felt that lubrication with oils under heavy pressures is an artificial system, for the friction is supported by a thin film of oil which must separate completely and continuously the bearing surfaces. If this film be in the least broken, even in minute places, there will be a catch between the metal surfaces with greatly increased friction, as shown by higher temperatures as well as by higher coefficients. This uncertainty in oil lubrication depends on an inherent weakness of the hydrocarbons which constitute the main body of petroleum lubricants, assuming that they have been separated from the crude oil without decomposition in the process of refining; they are few in number, and members of a limited series represented mainly by the general formulas $C_n H_{2n}$, $C_n H_{2n-2}$, and $C_n H_{2n-4}$. The limited number of hydrocarbons in these series is shown by the fact that they may be collected within comparatively narrow limits of temperature during distillation, provided, of course, that decomposition is avoided. The stability of these hydrocarbons diminishes in a somewhat regular manner with the increase in complexity of composition, until a point is reached where the oils cannot be distilled without cracking even *in vacuo*. This variation in stability appears in their use as lubricants, especially under irregular conditions of friction and temperature. But so long as the temperature is kept down and the bearings have a properly even surface, the hydrocarbons of suitable viscosity serve as durable lubricants. Under uneven conditions of friction they are liable to immediate decomposition even to carbonization. This complete decomposition is frequently observed especially in the extremely variable conditions of automobile lubrication. In fact the demands of modern locomotion with unprecedented high speeds, such as in automobile racing, uneven loads, and the variable changes of highway traffic, have reached a burden of lubrication that no oils, mineral, vegetable, or animal, are capable of supporting. Carbonization in automobile lubrication is an occurrence of common observation, and oils are rated on the basis of a so-called carbon test, which shows certain differences in stability depending on a difference in the composition of the oils, and also on the method of refining. No oils can withstand the regular operations of certain automobile practice without carbonizing to a greater or less extent.

Lubrication with oils is based on the quality of oiliness, or greasiness that is inherent in the hydrocarbons poorer in hydrogen mentioned above. It is not strictly defined by viscosity as ordinarily determined. While the molecules have a certain freedom of motion within the body of the oil attended with a consequent inherent friction, they have also an attraction for external surfaces on which they may form an attachment, but preserving their continuity and freedom of motion even under high pressures and high speeds, thus forming, under constant conditions, a continuous and a durable film.

Engler[3] in referring to oil lubricants stated that "Das Schmiermittel par Excellence" is not known, but that for every special use a lubricating oil must be selected on the basis of its viscosity; that since for variable combinations of pressure and speed, there is no definite standard, the viscosity must be determined for any set of conditions in practical operation. It may be said further that viscosity as ordinarily de-

* Reproduced from *The Journal of Industrial and Engineering Chemistry*.

[1] *Journal of the American Society of Mechanical Engineers*, January, 1910.

[2] At the time of the former publication the term "deflocculated" was used to designate this form of carbon which had been found to be altogether different in its properties from the other well-known forms. Further study demonstrated its colloidal quality.

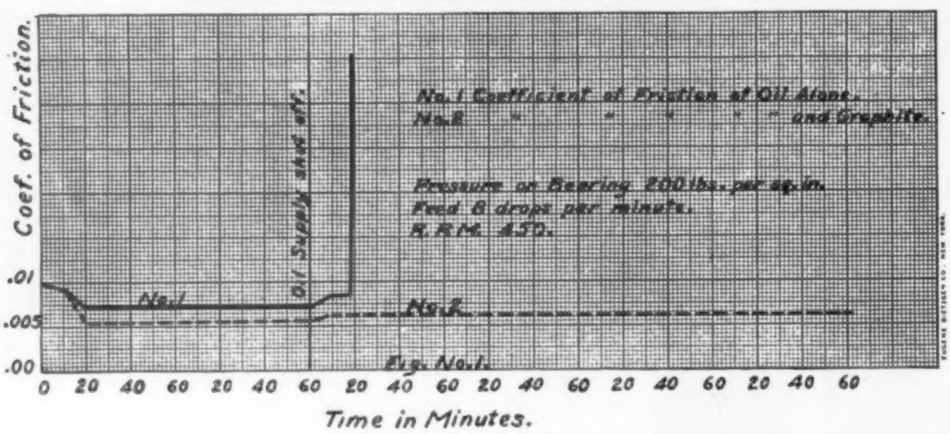
[3] *Das Erdoel*, Leipzig, 1812, p. 83.

termined is not always reliable for determining the quality of a lubricating oil for any stated condition, for the reason that it is possible to prepare an oil lubricant by compounding a heavy distillate with a lighter one, leaving out the middle fraction, in such a manner as to give any viscosity desired as determined by the viscosimeter. But in the use of such a lubricant there is a tendency of the lighter constituents to creep and evaporate, leaving the heavy constituents between the bearing surfaces. It is evidently possible to determine the presence of any considerable amount of the lighter constituents by determining the flashing point of the oil, but this test is scarcely sufficient to indicate with precision the presence of such proportions of the lighter constituents as may be used to give the desired viscosity. A more accurate means of control is distillation which, if conducted in *vacuo*, should show the smallest proportion of lighter oils. A further aid from a practical point of view, and one that is highly desirable if properly conducted with reference to factory use and conditions, is the trial of an oil on a suitable bearing provided with the means for ascertaining the coefficient of viscosity and for reading temperatures.

On account of the inherent weakness in oil lubricants referred to above, the need is evident of a solid lubricant capable of equalizing the inequalities of the metal surfaces and of such adequate lubricating quality as to avoid intermolecular friction. Of all known materials the substance graphite alone possesses the qualities of a normal lubricant. In its ordinary natural condition it is not possible to mechanically subdivide it so completely that it can penetrate the fine interstices of metallic surfaces and at the same time form a persistent coherent lubricated surface; but in a form of complete purity, free from the mineral constituents of natural graphite and in a condition of minute subdivision, such as is formed by the conversion of Acheson's electric furnace graphite into its colloidal condition, there is available a solid lubricant that fulfills the requirements of economic lubrication. It is so finely divided that it readily permeates metals and by reason of its unctuous quality its own friction is reduced to a practically negligible quantity, thus escaping the internal friction of oil lubricants that is an important factor in the losses of power.

The action of colloidal graphite is two-fold: its permanent suspension in oil as oildag or in water as aquadag renders it capable of convenient application and it invariably reduces the viscosity of the oil as a medium of application as shown by many tests with a great variety of oils; its greatest value, however, depends on its readiness to form a graphoid condition on bearing surfaces. It is only necessary that it be suspended in a suitable medium free from any kind of electrolyte to give the finely divided particles freedom of motion. When evenly spread in an oil medium over a bearing surface such, for example, as a Babbitt bearing of the proper quality, the colloidal particles immediately enter the fine metallic interstices and accumulating from a combination somewhat analogous to an amalgamated surface, which needs only to be properly renewed by regular additions of the lubricant to present a bearing surface capable of supporting any reasonable pressure and with the lowest friction that it is possible to obtain.

Chart for Motor Oil with and without 0.35% Colloidal Graphite



In the description of the Carpenter machine on which the tests presented in this paper were made, in the former paper referred to above, the necessity of using a hard Babbitt bearing was mentioned. The condition of the journal and of the bearing have been more carefully considered in the recent work, especially with reference to the hardness of the Babbitt, the smoothness of surface, and the even distribution of the lubricant by the grooved bearing. It is evident that observations of this nature are altogether relative, especially as it is practically impossible that independent bearing surfaces are precisely in the same condition. By the use of a standard lubricant it is of course possible to compare tests made under different conditions.

In the work herein described an especially hard Babbitt was selected, and the bearing surfaces were milled down to true contact in the beginning, and by long-continued use were worn to as extreme a condition of fine smoothness as it is possible to obtain by ordinary mechanical operation. Comparing the extremely low coefficients and temperatures recently obtained with those formerly presented, the difference in the condition of the bearings is evident. While these conditions are necessary in showing small differences of friction, evidently no such strict adherence is necessary in factory operation, although the more closely they are applied in practice the less will be the loss in power. Under any reasonable conditions of operation the use of colloidal graphite as lubricant is certain to reduce the friction very materially and to serve as an important economic element in factory maintenance.

For the purpose of ascertaining with greater precision than formerly the influence of colloidal graphite in reducing friction, observations were made under a variety of conditions, more especially for the purpose of comparing its superior economy over that of oil lubricant. First in the series of tests one of the best automobile lubricants, was selected for a test of its frictional capacity alone, and then with different percentages of graphite. The oil was allowed to run from the cup at the rate of eight drops per minute for two hours, with a thermometer inserted in a hole in the bearing for the purpose of reading the temperatures. The pressure selected was 200 lbs. per square inch or a total of 1,500 lbs. The speed was 450 revolutions per minute.

Fig. 1 shows the coefficients of friction extending through the period of the test, two hours, and also that the oil film broke seventeen minutes after the supply was shut off.

It should also be mentioned in connection with this observation that a supply of eight drops per minute of the lubricant is the minimum amount of this oil that will support the friction of this pressure under these conditions. This was determined in another experiment, wherein the flow of oil was reduced to six drops per minute; the oil film broke soon after the test was started showing that this quantity of oil was insufficient, a result precisely similar to what was observed in the work three years ago with the same oil and with other oils. The low coefficient of friction in this test is worthy of note, and also its evenness after normal conditions were established, and until the oil film broke.

Chart for Motor Oil with 0.25% Colloidal Graphite

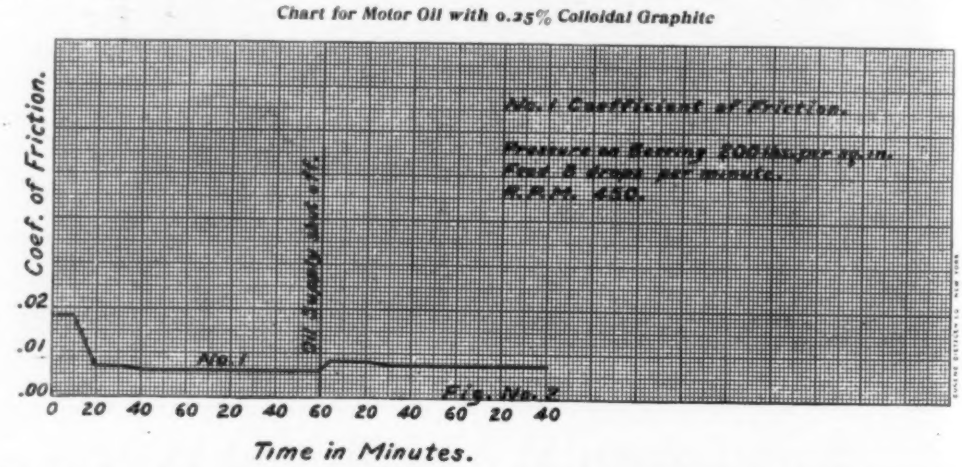
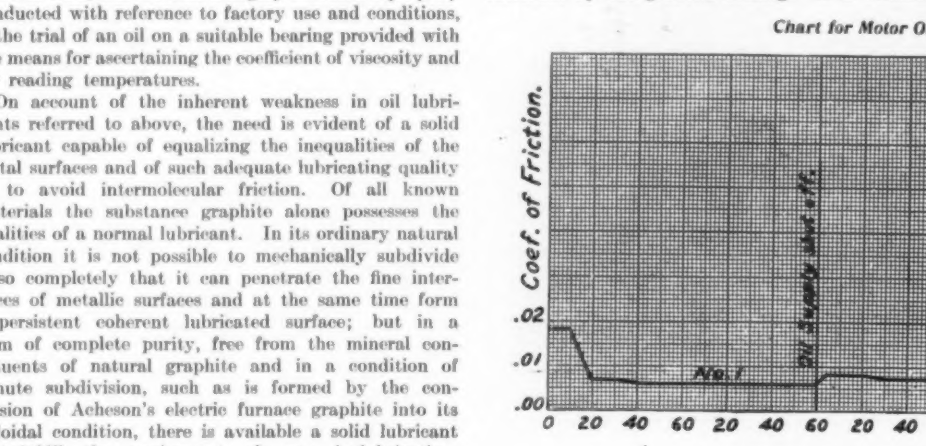


Fig. 1 also presents the curve for the same oil carrying 0.35 per cent graphite under the same elements of pressure, speed, and supply of oil to the bearing. The low coefficient of friction is apparent which, with a corresponding lower temperature, indicates clearly the influence of the graphite in reducing the viscosity of the oil, but the observation of especial interest in this test is the permanence of the graphoid surface after the supply of lubricant was discontinued. It appears that this surface supported a pressure of 200 lbs. ppr square inch with an extremely low and even coefficient of friction that continued unchanged during five hours and would probably have continued much longer.

For the purpose of ascertaining whether larger or smaller percentages of graphite are advantageous, several runs were made with lubricants carrying 0.5 per cent and smaller percentages to 0.1 per cent, but neither of these extremes were satisfactory. Fig. 2 presents the results as to coefficient with the lubricant carrying 0.25 per cent of graphite under a pressure of 150 lbs. per square inch. The results of this test are not essentially different from those of Fig. 2 with 0.35 per cent graphite, although the coefficients are somewhat lower with the larger percentage. There is therefore little to choose between these percentages in establishing the initial graphoid surface; but as will be shown later a suitable surface can be permanently maintained when it is once established by a much smaller addition of lubricant, whether it be used as a smaller percentage of graphite, or by a diminished supply of oil carrying the normal proportion.

For the purpose of ascertaining the minimum amount

Chart for Endurance Tests. Oil and 0.35% Colloidal Graphite



of graphite that will maintain a graphoid condition when once formed on the bearings, a series of tests were made gradually reducing the supply of lubricant all under the same conditions of pressure and speed. Fig. 3 gives the curves after the flow of oil was reduced from eight to four drops per minute, the oil containing 0.35 per cent graphite. It will be observed that the oil ran for six hours with the coefficient of friction practically unchanged after normal conditions were established.

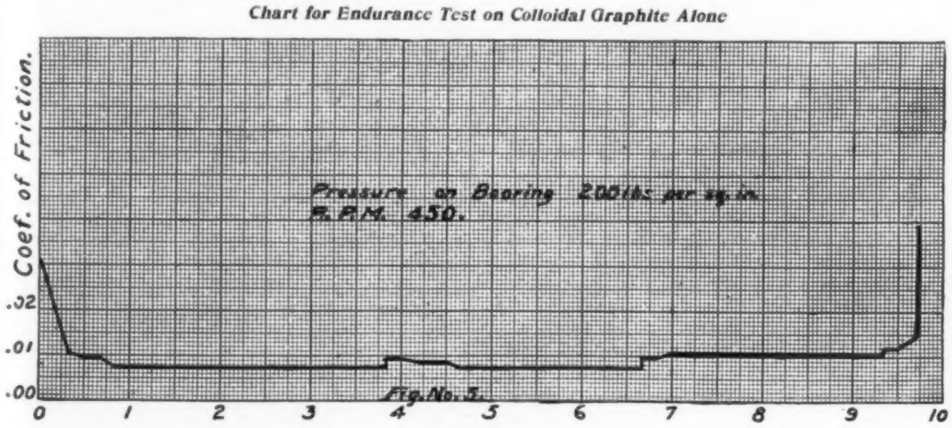
It seems advisable to give in detail the results of these tests in order that their connection with the final result may appear. Fig. 3 also gives the results of a further test of the same graphoid surface with the flow of oil reduced from four to two drops per minute; as before, the coefficients remained practically the same during fifteen hours with slight breaks due to stopping and starting.

Still continuing the endurance tests, the bearings were allowed to run on the same surface and under the same conditions as before, except a reduction in the supply of lubricant from two drops to one drop per minute. Fig. 3 presents the results of this test with no change in the coefficient.

Fig. 4 presents another test of the graphoid surface under the same conditions as to pressure and speed, but with the flow of oil reduced to one drop in two minutes. During this run of sixteen hours it will be observed that the coefficient of friction remained constant and there was no change in temperature. Since the coefficient of friction in this test was unchanged at the end of sixteen hours, even a greater reduction in the flow of lubricant would evidently have maintained the graphoid surface, but this flow was practically at the lowest point where it could be accurately measured from the oil cup.

It appears, therefore, that the same result in lubrication is obtained by the use of one sixteenth of the quantity of oil that is necessary to maintain the same lubrication without the use of colloidal graphite; for

Chart for Endurance Test on Colloidal Graphite Alone



it was shown that a flow of eight drops per minute is the minimum supply of oil alone that will support the friction under these conditions.

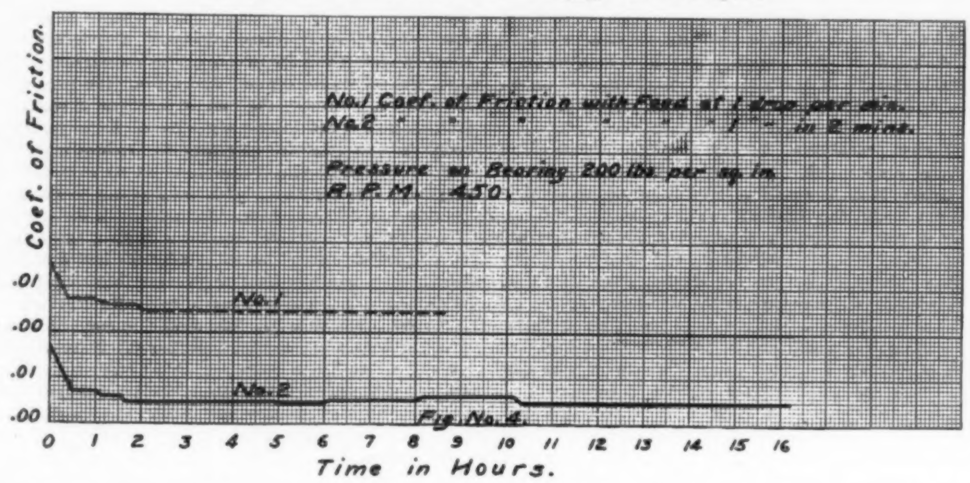
For the purpose of testing still further the quality of the graphoid surface, at the end of the last test the flow of lubricant was suspended and the machine allowed to run until the bearing caught. The results of this test are shown in Fig. 5 where it appears that the pressure was supported for nearly ten hours and with a coefficient only slightly higher than in the preceding tests. It should be borne in mind that a break in the continuity of the lubricated surface is indicated suddenly by a great rise on the friction arm and it is caused by the first point or section however minute wherever the graphite becomes worn through, yet there may still be a large section of lubricated surface. This appeared in the next experiment.

The manner in which colloidal graphite is able to support such heavy pressures with low friction has already been explained. After the metallic surface becomes completely saturated with graphite evidently without renewal, continued friction would be necessary to remove it completely. It therefore seemed of interest to ascertain how readily it could be removed. A series of runs were made on the same surface after it broke in the last test, with the addition of oil alone at the rate of eight drops per minute, to determine just the point where the graphoid surface could no longer assist in lubrication. In each of the runs the oil was allowed to flow for thirty minutes, and the bearings were then carefully wiped. Fig. 6 shows the effect of the graphite in assisting the oil lubrication without change during six runs, and also that it became exhausted and broke in the seventh run showing that altogether approximately three and one half hours were required to wear off the graphite until it was no longer an aid in lubrication.

A GRAPHOID SURFACE AND THE CONDITIONS OF ITS FORMATION.

In the former paper on this subject[4] the effect of colloidal graphite (then referred to as a "deflocculated form") appears the following statement: "One of the most characteristic effects is that of a surface-evener, by forming a veneer, equalizing the metallic depressions and projections on the surfaces of journal and bearing." After four years experience with graphite lubrication it appears that the former explanation falls short of defining the intimate relation of colloidal

Chart for Endurance Tests. Oil and 0.35% Colloidal Graphite



graphite to metallic bearings. No doubt in building up the graphoid surface the entire depressions and projections are saturated with graphite which doubtless enters into a closer state of combination with the metallic surface than that merely of a mechanical veneer.

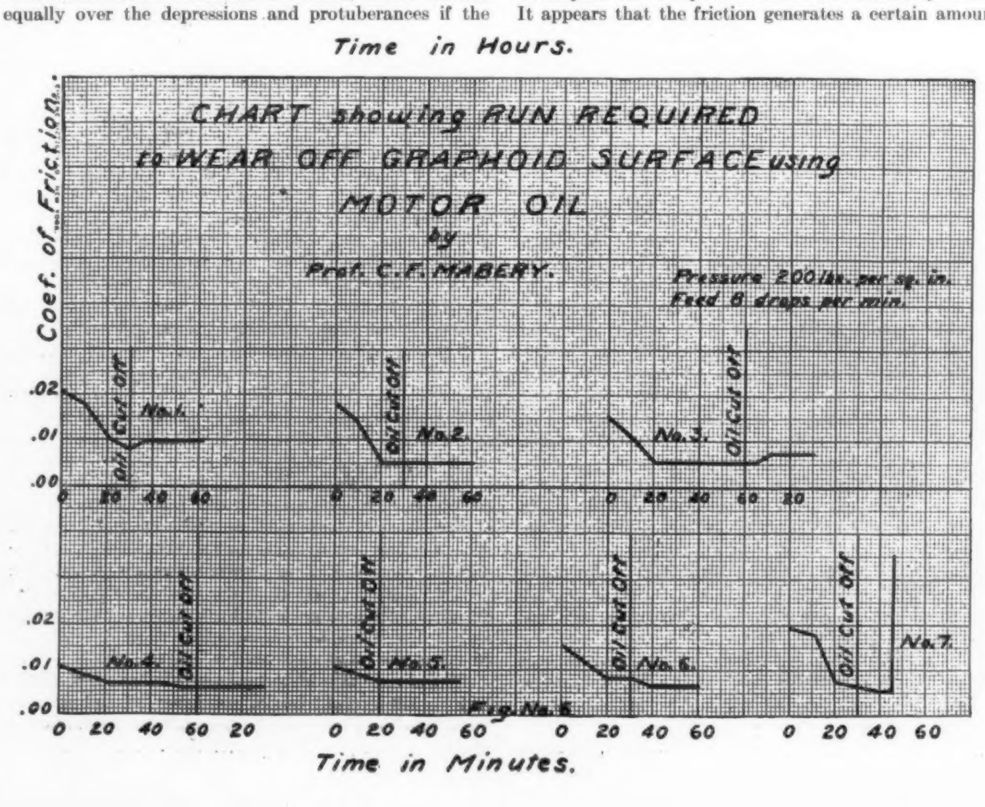
In the use of colloidal graphite as a lubricant it appears that by reason of the tenuity or fineness of its particles, it is capable under the conditions of lubrication of penetrating the porous surface of metals, and coming into such close contact in their intermolecular structure, of approaching a condition of graphitic combination. It then continues to accumulate until a continuous saturated surface is formed, which extends equally over the depressions and protuberances if the bearing is not in the best condition of smoothness; but in its best condition the graphoid surface formed seems to be nearly frictionless.

Since this relation of metal and carbon is not defined by any term now in use, the word *graphoid* used above may distinguish it from the term *film* that expresses the state of an oil lubricant on a bearing surface.

As to the greater efficiency of the graphoid surface over an oil film under any conditions of lubrication there seems to be no question. It all depends on establishing the conditions whereby this surface may be readily formed. An oil medium in which the colloidal graphite is permanently suspended can evidently carry it to any form of bearing surface that needs lubrication. Whatever the condition of the metallic bearing the graphite soon combines with it, and the smoother the surface the more readily will a continuous graphoid surface be formed. In all tests it has appeared that the internal friction of an oil is diminished by colloidal graphite, although its larger effect is altogether independent of oils except as a medium of application. After a graphoid surface is formed only a small continuous addition is necessary to replace the wear which, as shown in the tests, reduces the consumption of oil to a small fraction of what is necessary in the use of oil alone. While eliminating the internal friction of oils and rendering viscosity of secondary importance, the graphoid surface is capable of taking care of light and heavy pressures equally well and with a minimum loss of power.

RELATION OF COEFFICIENT OF FRICTION AND VISCOSITY TO TEMPERATURE.

Since the curves for temperatures were found to follow closely those of friction practically unchanged, it was not thought necessary to plot them. In all the observations described in this paper, it was observed that the temperature gradually increases with the duration of the test until it reaches a practically constant value not exceeding 65 deg. Fahr., and that for the most part the temperatures were considerably lower. It appears that the friction generates a certain amount



[4] *Loc. cit.*

of heat until it reaches a normal which is practically constant, and that beyond this point the increase if any is so slight that it is dissipated. In general the lower the coefficient of friction, the lower will be the temperature. This is shown in Fig. 1, where the temperature and the coefficient for oil alone were considerably higher than those for oil carrying 0.35 per cent graphite. It also appears in the other charts especially in the endurance tests, with a small supply of oil. This is doubtless explained, in part at least, by the internal viscosity of the oil which is of course less with the smaller supply of oil aided by the graphite, and it demonstrates a superior quality of the graphoid condition over an oil film, in eliminating practically internal viscosity.

AUTOMOBILE LUBRICATION.

There is probably no variety of lubrication in which colloidal graphite shows its economic value to better advantage than in reducing the friction on automobile bearings. On the Babbitt bearings of the cylinder shaft it readily forms a graphoid surface that wears indefinitely, and the self-lubricating quality of this surface reduces friction to the smallest possible value. It eliminates also any possibility of heating due to an irregular flow of oil. In the wide and sudden variations of highway automobile traffic the bearings are often subjected to greater strain than an oil film can stand, but not a graphitized surface when once well formed. Such protection from undue wear and sudden strains that cannot be avoided in highway locomotion adds greatly to the safety and length of service of the finely adjusted mechanism. Assuming properly selected materials in construction, no doubt the most uncertain element in the proper operation and in the economic durability of an automobile is the friction of its moving parts. Its sure control protects the mechanism of the moving parts and reduces expense.

The Number of Medical Students in Germany

One of the consequences of the introduction of National Insurance in Germany has been the growing number of students of medicine, and the sick clubs do their utmost to promote the recruiting to the ranks of the medical profession, as by this means they hope to be able to keep the rates of remuneration as low as possible by fostering competition in the struggle for life among the doctors. These steadily growing numbers are now becoming a serious menace to the future of the profession, and the situation is viewed with some apprehension. During the past winter semster there were in all 13,380 students of medicine inscribed on the rolls of the German universities, against only 5,926 in the years 1904 and 1905. The number of practitioners obtaining their qualification at present increases at the rate of 150 yearly, so that from a total of 1,650 obtaining their qualification in 1913 and 1914, this number will increase to 2,500 in 1919 and 1920. At present there are 33,527 qualified medical practitioners in Germany, and assuming that the annual loss to the profession through death or retirement averages 650 in the years 1919 and 1920, there will be no less than 44,227 doctors endeavoring to find a livelihood out of their professional work. It is pointed out that such a state of affairs must lead to an economic catastrophe, as at least one third of these practitioners will be unable to make a living.—*The Lancet.*

Ozone

By A. M. Buswell

A striking example of the danger of commercializing a popula notion without first subjecting it to proper tests is brought out in two articles in the *Journal of the American Medical Association* for September 27th, on the Purification of Air with Ozone. We were taught in our "Prep" school chemistry that it was the "ozone of the country air" which was responsible for the health and longevity of the rural population; and of course the healthful effect of ozone we inferred was due to its value as a disinfectant. Furthermore, ozone is an energetic oxidizing agent; so is hydrogen peroxide; hydrogen peroxide is a germicide; so, we thought, was ozone.

Ohlmüller's experiments, twenty years ago, together with those of several investigators since, discrediting its germicidal action, did not shake the popular faith in ozone. Public officials have readily accepted claims such as the following: (1) Ozone is a necessity for the d struction of infectious germs, for the sterilization of air in operating rooms, for the purification of air in homes of persons suffering from contagious diseases, and for giving to offices and homes the invigorating air of country, seashore and mountain. (2) Ozone cannot exist except momentarily in air containing organic matter, and therefore the presence of ozone is an indication that the air is sterile and devoid of organic matter. (3 Ozone is unique as a germicide by reason of the fact that it has no deleterious effect on the higher forms of animal life, owing to the low percentage of carbon in their structure.

In the first of the two articles mentioned, "Ozone: Its Bactericidal, Physiologic and Deodorizing Action," by E. O. Jordan, M.D., and A. J. Carlson, M.D., of Chicago, the authors describe an extensive series of experiments undertaken by them at the suggestion of, and under a grant from, *The Journal of the American Medical Association.* Their investigation was complete and exhaustive and their data fully justify their conclusions and summary which we quote:

"So far as the destruction of bacteria is concerned, ozone has little or no value. Some bacteria are undoubtedly killed by ozone, especially if they are in a moist condition and are in contact for several hours with a current of ozone coming direct from the generator. In practice, however, the fact is of slight importance. Human beings are injuriously affected by amounts of ozone far less than are necessary to produce even this slight bactericidal effect, and there is no evidence for supposing that a quantity of ozone that can be tolerated by man has the least germicidal action. If disinfection of a closed room without inmates is deisred, this can be much more effectively carried out by the use of formaldehyde or some other familiar gaseous disinfectant than by ozone. Ozone has no place in room disinfection.

"Ozone is not an actual 'deodorizer' in concentrations that can obtain in practical ventilation. In very great concentrations ozone seems capable of oxidizing some odorous substances so that the odors are diminished or changed, but the change may be in the direction of increasing the disagreeableness of the odor. In very great concentrations ozone 'masks' most odors by its own intensive odor, and possibly by fatigue or anesthesia of the olfactory epithelium. Certain odors are masked by ozone even in weak concentrations. Is such masking of odors desirable and generally advantageous? We think not. It is probable that the injury to the respiratory tract by ozone in sufficient concentration to act as an effective mask is of greater moment than the deleterious action of most odors. Except in special industrial processes, the unpleasant odor of the inspired air in shops, offices or living rooms is usually a sign that the air needs to be renewed or changed. Why should we put out of commission the sense organ which aids us in determining whether or not the air is fit to breathe? It seems to us that this is wrong in principle, and that ozone is being used and will be used as a crutch to bolster up poor ventilating systems. Ozone does not make 'pure air' any more than strong spices make pure food.

"In concentrations that appreciably affect man and animals, ozone appears to have uniformly an injurious action. This injurious action is primarily on the respiratory passages—irritation of the sensory nerve endings, and irritation, corrosion and depression of the epithelial cells. The depression of the alveolar epithelium leads to changes in the gaseous exchange in the lungs, and secondarily to changes in the blood, and ozone headache, depression and drowsiness are produced.

"Hill and Flack [*Proc. Roy. Soc.*, 82, 404 (1911); *Jour. Roy. Soc. Arts.*, 60, 344 (1912)] point out that ozone gives a certain 'tang' to the air, and thus relieves the impurity (temperature and moisture) which is apt to obtain in offices and assembly rooms. This tang is a combined effect of ozone odor and the ozone irritation of the sensory nerves in the respiratory tract. We have seen that this acts (reflexly) on the vascular mechanism and it may temporarily 'whip up' a fagged brain. But is this ozone tang many more beneficial or any more physiologic than a whiff of smelling-salts or a puff of the cigarette? We recognize that a certain amount of variation in the rate of movement and in the temperature of the air about us aids in maintaining the tonus of the brain, but our ventilation engineers must reproduce the variability of outdoors by actual variations in the air and in the rate of movement of the air in the ventilating systems, and not by adding a poisonous gas to the air. Nor can we accept the suggestion of Hill and Flack that small amounts of ozone may be of therapeutic value in certain diseases of the respiratory tract by reason of the hyperemia following the ozone irritation. The cells injured by ozone are probably more readily invaded by bacteria, and have less than normal power of growth and healing despite the hyperemia. And all bacteria cells of the respiratory tract of man and experimental animals. The physiology of ozone points to the conclusion that the use of this poisonous gas as a therapeutic agent is either valueless or injurious."

The second article, "The Alleged Purification of Air by the Ozone Machine," by W. A. Sawyer, M.D., Director of the Hygienic Laboratory of the California State Board of Health, and his co-workers, Beckwith and Skolfield, though not as extensive, is no less convincing than the first. The conclusions of these authors are quoted also:

"The gaseous products of the two well-known ozone machines examined are irritating to the respiratory tract and, in considerable concentration, they will produce edema of the lungs and death in guinea pigs.

"A concentration of the gaseous products sufficiently high to kill typhoid bacilli, staphylococci and streptococci, dried on glass rods, in the course of several hours, will kill guinea pigs in a shorter time. Therefore these products have no value as bactericides in breathable air.

"Because the products of the ozone machines are irritating to the mucous membranes and are probably injurious in other ways, the machines should not be allowed in schools, offices or other places in which people remain for considerable periods of time.

"The ozone machines produce gases which mask disagreeable odors of moderate strength. In this way the machines can conceal faults in ventilation while not correcting them. Because the ozone machine covers unhygienic conditions in the air and at the same time produces new injurious substances, it cannot properly be classed as a hygienic device."

It is to be hoped that the results of these investigators will receive sufficient publicity to correct popular ideas on the germicidal action of ozone and that the work will not have to be repeated as in past years. —*Journal of Industrial and Engineering Chemistry.*

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